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Determinants of international transmission of business cycles to Turkish economy

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ABSTRACT

This study aims to investigate the channels through which international business cycles are transmitted to Turkish economy. Our analysis follows two steps: i) business cycle transmission is measured using Longest Common Subsequence (LCS) method, a pattern recognition algorithm that accounts for the nonlinear and time-varying nature of business cycles and ii) the potential mechanisms of propagation of international business cycles are examined by specifying a panel regression model in which the LCS measure of synchronization is used as the dependent variable. Applying several panel estimation methods to the bilateral data from 22 countries over the 1998–2009 periods, we find that both trade and financial similarities are significant in the transmission of business cycles to Turkish economy. Especially, the results highlight the role of trade integration indicating that Turkish business cycles are closely linked with the business cycles of the members of European Custom Union.

1. Introduction

Along with the liberalization and globalization waves that began in the early 1980s, international flows of goods, services and capital accelerated, laying the groundwork for the integration of economies all around the world. This may not only lead the world economies to responding to common shocks altogether and more rapidly but also deepen and diversify the mechanisms of transmission of international business cycles. Obviously in such a world, business cycle of a country is inevitably subject to the macroeconomic shocks above and beyond its domestic shocks. In addition, while shocks in a country can be transmitted to others, business cycle of a country can be influenced more by external than by domestic shocks. Influenced by these waves and with the desire to be integrated with the global world, Turkey started reducing its trade barriers in the 1980s and liberated international capital movements fully in 1989 and joined into the European Custom Union in 1996. While these course of actions enabled the Turkish economy to become more integrated with the world economies, they also increased the exposure of the Turkish economy to global shocks and market sentiments. This has raised concerns that when industrial countries sneeze, the emerging market economies like Turkey catch a cold. Although the experience of a prolonged and stable growth in the emerging markets such as China and India after the economic crisis in the US in 2001 gave rise to the impression of decoupling of international business cycles, the economies seemed to behave more synchronized after the recent crisis in 2008. Under these circumstances, the design and implementation of stabilization policies with the focus on just the domestic conditions are likely to be insufficient and inefficient. Therefore, the stabilization measures should be planned taking into consideration the questions of how and through which channels international business cycles are transmitted to domestic economy. The objective of this study is to seek answers to those questions from the perspectives of Turkish economy that has been becoming more and more integrated with the global economy over the last three decades.

The empirical studies examining international transmission of business cycles tackle with two valid concerns: nonlinearity (and asymmetry) in business cycles and time-varying nature of transmission of business cycles (Artis et al., 2007; Canova et al., 2007; Carera and Mody, 2010; Eickmeier, 2007; Yi, 2009). While nonlinearity is taken into account using MS-VAR (Markov Switching) or ST-VAR (Smooth Transition) models (Chen, 2009; Girardin, 2005; Osborn et al., 2005; Taştan and Yıldırım, 2008), the issue of time-varying transmission is addressed using rolling windows. For examples, Yılmaz (2009) applies a multivariate VAR while Cerqueira and Martins (2009) calculate the dynamic correlation coefficients of business cycles over rolling windows. Unlike the previous work, our methodology allows us to address these issues at once. Our study proposes a distinct approach to measuring synchronization of business cycles: Longest Common Subsequence (LCS). There are several novel features of LCS: i) it is a distance that is used for analyzing interdependency of time series successfully under the presence of nonlinearities, noises and outliers and ii) it allows for time warping, making it suitable for taking into consideration the time-varying nature of the propagation mechanisms of international business cycles, iii) it is adoptable to account asynchronous but similar patterns since it provides similarity of shapes.

Employing LCS enables us to obtain a measure for the degree of international business cycle transmission which is then defined as the dependent variable in a panel regression model in order to examine

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the question of which channels are operational for the international transmission of business cycles to Turkish economy. There are a number of factors put forward in the related literature that are thought of fostering international propagation of business cycles. These factors take their roots mainly from the process of globalization over the last three decades. In this regard, international trade and finance channels are viewed as the most influential mechanisms in the transmission of business cycles. Nonetheless, the theoretical work on the subject documents several opposing mechanisms through which international trade and financial linkages can affect international propagation of business cycles. Thus, the question at hand needs scrutinizing empirically. In doing so, combining LCS method and panel regression models, we apply several panel estimation techniques to the bilateral data from 22 countries over the 1998–2009 periods. The results show that trade and financial linkages are significant in the transmission of business cycles to Turkish economy and especially that Turkish business cycles are closely linked with the business cycles of the members of the European Custom Union.

The rest of the paper is organized as the following. The first section reviews the theoretical and empirical studies on the subject. The second section lays down the methodology, giving a technical discussion on the LCS algorithm and specifying the panel model. The third section presents the data and empirical results. The last section concludes the study.

2. Literature review

There is a vast literature on the transmission and synchronization of international business cycles. One strand of the literature focuses on the question of whether there exists a global (world) business cycle using a dynamic factor analysis and factor structural VAR analysis (Köse et al., 2008; Stock and Watson, 2005). The presence of a world business cycle means that business cycles move together closely because of transmission channels and/or common shocks. Thus, the next step is to distinguish the effects of country specific shocks, common shocks and spillover of business cycles. For instance, Köse et al. (2003) finds evidence in favor of the presence of a world business cycle that is attributed to the increasing globalization process during the 1990s. Similarly, the studies by Otto et al. (2001), Köse et al. (2008) and Flood and Rose (2010) document supporting results. However, Heathcote and Perri (2004) for developed countries and Doyle and Faust (2005) for G-7 countries show that there is a decline in the linkage between business cycles of the US and industrialized countries. Another strand of the literature examines the transmission of business cycles employing a VAR, structural VAR, Markov-Switching VAR or Smooth Transition VAR analysis from the perspective of a specific country in a bilateral basis (Chen, 2009; Girardin, 2005; Osborn et al., 2005; Sayek and Selover, 2002; Taştan and Yıldırım, 2008). For instance Sayek and Selover (2002) examine the question of which transmission channels are operational between Turkish and European (proxied by Germany) business cycles in a SVAR framework. They find that the business cycles of Turkey and Germany are not synchronized and that only the fluctuations in national income and consumer prices in Germany are weakly transmitted to Turkish cycles. Another strand of the literature examines the question in a core-periphery framework investigating whether there exists Europeanization or globalization of business cycles with an application of a clustering analysis (Artis, 2004). This line of research first calculates a measure for synchronization of business cycles and then applies a clustering algorithm such as fuzzy c-means, hard clustering or model-based clustering (Artis and Zhang, 2001, 2002; Camacho et al., 2006, 2008; Crowley, 2008; Ferreira-Lopes and Pina, 2011). Finally, another strand of the literature following the study by Frankel and Rose (1998) picks up the issue in a panel regression framework in which a measure of synchronization is regressed on several transmission mechanisms of business cycles (Baxter and Kouparitsas, 2005; Flood and Rose, 2010; Inklaar et al., 2008; Kalemli-Özcan et al., 2009; Shin and Wang, 2004). Cross-country correlation coefficient is most commonly used as a measure of synchronization in this line of research. Further, these studies employ measures such as concordance, cohesion, dynamic correlation coefficients (coherency) developed by Croux et al. (2001) in spectral domain in order to represent interdependencies between cycles (Aguiar-Conraria and Soares, 2011; Allegret and Essaadi, 2011).

Interdependency between two time series can be measured with an application of similarity/dissimilarity measures. In general, these measures classified in two categories that are "structural" and "shape" similarity measures (Keogh et al., 2003). Structural similarities are model based (like ARIMA, stochastic differential equations) measures and they may find two different time series very similar under the lack of proper theories. Shape similarity measures are focused on the trajectory similarity and hence they produce closer result to the visual similarity. Shape similarity measures are used specifically for short time series since the modeling may result in high standard errors in estimation of the model parameters and hence structural similarity may result in inconsistencies (Wang et al., 2006).

Probably the most widely used time series similarity measures are Euclidian distance and the (cross-) correlation measures (Agrawal et al., 1993; Chan and Fu, 1999; Chu and Wong, 1999; Faloutsos et al., 1994; Keogh et al., 2001; Popivanov and Miller, 2002). These standard measures perform poorly under the conditions of outliers, significant noises, stretching/relaxing as well as asynchronous but similar patterns (Hoppner, 2002a; Jachner et al., 2007). Several high level representations are proposed to overcome this problem such as, Fourier transform (using 5–10 strongest waves as representation), Wavelets, Local Polynomial Representations, Eigenwaves, non-linearity, chaotic time series (Lin et al., 2007; Wang et al., 2006).

Capturing the similarities in a more abstract way as humans do is also a central work for many knowledge discovery algorithms. Majority of the algorithms to extract knowledge from time series start with abstraction and apply the similarity measures. For example, Hoppner (2002b) suggests three steps to analyze interdependencies: i) *labeling* (or describing the patterns as "*convex*", "*concave*", "*convex–concave*", "*concave–convex*", etc.) numerical values, ii) finding the patterns and iii) deriving rules about pattern dependencies. Two commonly used algorithm to measure pattern similarities between two time series that contain patterns varying in time and speed are Dynamic time warping (DTW) and Longest Common Subsequence (LCS) algorithms (Keogh et al., 2009). Both algorithms find an optimal match between two time series and allow for stretched and relaxed patterns. However LCS is found to perform the best among DTW and standard measures especially when time series are noisy and contain outliers (Vlachos et al., 2002). While LCS is used successfully in different context, to the best of our knowledge it is not employed to find out interdependencies between business cycles.

As for the transmission channels of business cycles, several determinants mainly pertaining to international trade and financial linkages are considered in this literature. The role of trade intensity as a transmission channel is ambiguous on theoretical grounds. Trade may lead to coupling or decoupling of business cycles. On the one hand, if an economy performs well due to a favorable demand shock, its trading partners get benefit from a rise in the demand for both domestic and foreign products, realizing an export-led growth (Canova and Dellas, 1993). Thus, the larger the trade, the stronger the interdependencies of business cycles among the trading economies. On the other hand, as predicted by the standard trade theories (Heckscher–Ohlin), if strong trade linkages result in industrial specialization, industry-specific shocks might be spurring an economy while slowing down another, leading to decoupling of the business cycles (Baxter and Kouparitsas, 2005). In particular, if the trade is mostly inter-industry in nature, it is more likely that industry structures become more disintegrated and that industrial specialization intensifies, under which conditions the impact of sector-specific shocks on business cycles will be negative (Eichengreen, 1992; Krugman, 1993). According to Krugman (1993), the conditions set by the European Monetary Union tend to give rise to industrial specialization and prevent the use of active and independent monetary policy for stabilization purposes and thus the business cycles of the member countries are more likely to be less correlated. Kalemli-Özcan et al. (2001) reach a similar conclusion. In contrast, if countries are vertically integrated, a productivity shock influences all economies in a similar fashion, leading to more synchronized business cycles (Köse and Yi, 2001). Similarly, Frankel and Rose (1998) argue that the business cycles of the countries in monetary union tend to move closely together if intra-industry trade overweighs inter-industry trade and if demand shocks dominate.

Empirical studies focusing on the effect of trade on business cycle synchronization mostly document a positive impact that has become more apparent especially after the second globalization period (Baxter and Kouparitsas, 2005; Heathcote and Perri, 2004; Köse et al., 2003). In a leading study by Frankel and Rose (1998) for 21 industrialized countries, it is found that trade intensity has a positive impact on business cycle synchronization. The following empirical studies usually document supporting results (Baxter and Kouparitsas, 2005; Calderon et al., 2007; Clark and van Wincoop, 2001; Otto et al., 2001). For instance Eickmeier (2007) considers the effect of consumer confidence index along with the trade channel and finds that the trade plays the most important role in business cycle synchronization between the US and Germany. Nonetheless, there are a few studies reporting insignificant effect of trade intensity on business cycle synchronization (Inklaar et al., 2008). Furthermore, Shin and Wang (2004) document that it is the structure of trade (intra-industry trade), not the bilateral trade intensity, affecting the interdependencies of international business cycles. In addition, Carare and Mody (2010) find that a rise in vertical integration in recent years results in an increase in the trade intensity of vertically integrated products, bringing about highly correlated business cycles. According to them, emerging market economies entering into the production and trade structures of vertically integrated global economy in the early 1990s appear to play a significant role in business cycle synchronization.

Another important transmission mechanism considered in the literature is the international financial mobility that has also intensified with the globalization process. Theoretical studies, however, identify opposing channels through which financial integration affects international business cycles. Within the framework of two-country general equilibrium models, there might be a negative linkage between financial mobility and business cycles (Baxter and Crucini, 1995; Obstfeld, 1994). According to Obstfeld (1994), international capital tend to flow in the sectors where the return from investment is higher, leading the countries to specialize in the industries with comparative advantage. Therefore, the resulting industrial specialization through the trade channel might inversely affect synchronization of business cycles. In addition, Baxter and Crucini (1995) predict that a positive productivity shock in a country increases the marginal productivity of capital, giving rise to investment demand and thus flow of international capital into that country. In this case, it is expected that the country experiences an economic growth while others experiences an economic slowdown. Taken as a whole, the fact that financial integration allows for a more efficient allocation of capital across economies might lead to less synchronized business cycles (Heathcote and Perri, 2004). Contrary to these studies, Krugman (2008) argues that a shock in asset prices in a county might generate “international finance multiplier” through balance sheet effects, bringing about a coherent investment behavior not only in the country experiencing the shock but also in the other countries linked with their balance sheets. For instance, when there is a mortgage crisis in a country, one expects deterioration in the balance sheets of international institutions (MNCs) holding these assets in their portfolios. This suggests that financial crisis in a country spills over quickly and easily in a financially integrated world, resulting in more synchronized business cycles. Devereux and Yetman (2010) provide a supporting argument, showing that, independently of trade integration, financial integration alone may play an important role in business cycles synchronization. In their study, under leverage constraint, financial integration is likely to bring about similar portfolio structures across countries, enabling balance sheet adjustments easily. This implies that financial openness plays a significant role in output comovement. There are a number of empirical studies in the literature finding a positive impact of financial integration on the business cycle synchronization (For instances, Davis, 2008; Imbs, 2004, 2006; Morgan et al., 2004). However the study by Kalemli-Özcan et al. (2009) appears to be an exception, which uses confidential data on international bank transactions taken from BIS to measure financial integration. They find an inverse relationship between financial integration and comovement of business cycles as the standard models predict.

Along with the international trade and finance mechanisms, the theoretical and empirical studies consider a number of important transmission factors such as consumer confidence index (Eickmeier, 2007), foreign direct investment (Hsu et al., 2011) and especially the roles of international policy coordination with regard to fiscal (Inklaar et al., 2008) and monetary policy strategies (inflation targeting) and regimes (exchange rate). For instance, Inklaar et al. (2008) show that business cycles of the countries with similar fiscal policies appear to be more synchronized. Also, the business cycles of the countries adopting floating exchange rate regime along with inflation targeting seem to be positively related. The rationale behind this is that floating exchange rate regime is likely to absorb external monetary shocks, leading to more synchronized business cycles. While the conceptual perceptions on the effect of inflation targeting that are more formalized with the work of Cespedes et al. (2004) are mixed, Flood and Rose (2010) find evidence that the outputs of the countries adopting inflation targeting are more likely to co-move closely.

2.1. Methodology

In order to analyze the factors that affect the transmission of business cycle from other countries to Turkey, we adopt a methodology that follows two steps: i) obtaining the degree of business cycle transmission and ii) analyzing transmission channels by means of a panel regression model. In what follows, we begin with measuring business cycle components.

2.2. Business cycle measurement

Burns and Mitchell (1946) describe business cycle as a cycle that consists of expansions, recessions, contractions and revivals in many economic activities. In general, fluctuation of activities seems to be repeating regularly with different duration and amplitude. Amplitude and duration may change cycle to cycle as well as phase to phase of business cycles such as expansion, recession, contraction and revival phases experience different duration and amplitude. In the literature, GDP and Industrial Production Index (IP) are used to obtain business cycles. In this paper IP data is used to this end for several reasons: i) the major part of fluctuations in GDP data can be attributed to industrial production, ii) the interdependencies between business cycles can be measured through common fluctuations and iii) IP data has more observations (monthly observation) than GDP.

Non-parametric filtering methods such as Hodrick and Prescott (1977, HP filter) and Baxter and King (BK filter) are commonly used to extract business cycle series in literature (Artis, 2002; Artis et al., 1995, 2003; Cashin, 2004). The aim of filtering is to obtain the series that represent the business cycles. Hence business cycle series should have similar periodicity to the observed business cycles. Burns and Mitchell (1946) observed that business cycles in the United States have periods between 6 to 32 quarters (or 18 to 96 months). Therefore those filters must filter out the components that have periods in this interval. BK filter accepts the upper and lower bound for band-pass filtering and thus some observation points are lost in the beginning and end of the sample period. On the other hand, HP filter which is a low-pass filter uses a smoother to obtain trend and high frequency components without losing any observation points. Thus, HP-filter with optimal smoothing parameter is employed to obtain business cycles of the countries in this paper. Accordingly, the trend component that minimizes the following quadratic function is used:

$$\min\{y_t^g\} \sum_{t=1}^{T}(y_t-y_t^g)^2+\lambda\sum_{t=2}^{T-1}\left[(y_{t+1}^g-y_t^g)-(y_t^g-y_{t-1}^g)\right]^2 \tag{1}$$

where, y_t^g is the trend component; λ is the smoothing parameter.

However there is no consensus on the value of the smoothing parameter, λ, it is generally set to 10, 1600 and 14,400 for annual, quarterly and monthly data, respectively (there are also some other values such as 129,600 used for monthly data after Ravn and Uhlig (2002)). In literature, λ estimator is linked to the ratio of the variance of the cyclical component to the variance of the second difference in time domain analysis. In frequency domain analysis it is linked to the transfer function of the HP filter (Dermoune et al., 2008; Hodrick and Prescott, 1997; Ravn and Uhlig, 2002; Schlicht, 2005). Estimation of the variances can be obtained with maximum likelihood or general methods of moment (Schlicht, 2005), but the consistency of the estimators is not guaranteed. To obtain a consistent estimator Dermoune et al. (2008) improve Schlicht (2005) approach under the assumption that the trend component follows unit-root Gaussian random walk. According to their approach, $y=(y_1,y_2,\ldots,y_T)$ is a time series that has non-stationary trend component and cyclical component then consistent estimator for λ is given as:

$$\hat{\lambda}=\max\left\{0,-\frac{1}{4}\left(\frac{3}{2}+\frac{(T-3)\sum_{j=1}^{T-2}Py(j)^2}{(T-2)\sum_{j=1}^{T-3}Py(j)Py(j+1)}\right)^{-1}\right\} \tag{2}$$

where P is a matrix as shown below.

$$P=\begin{pmatrix}1 & -2 & 1 & \ldots & \ldots & 0\\ 1 & 1 & -2 & 1 & \ldots & 0\\ & \ldots & \ldots & \ldots & \ldots & \\ 0 & \ldots & \ldots & 1 & -2 & 1\end{pmatrix}$$

2.3. Longest Common Subsequence for the degree of business cycle transmission

In order to measure business cycle interdependencies, the study employs Longest Common Subsequence (LCS) algorithm. LCS is a subsequence, S, of the maximal length between two strings, say A and B. $S=s_1,s_2,\ldots,s_p$ is a subsequence of both $A=a_1,a_2,\ldots,a_n$ and $B=b_1,b_2,\ldots,b_m$ where $p\prec m\le n$. Then the mappings are defined as, $F_A:\{1,2,\ldots,p\}\to\{1,2,\ldots,n\}$ and $F_B:\{1,2,\ldots,p\}\to\{1,2,\ldots,m\}$ such that $F_A(i)=j$ if $s_i=a_j$ (similarly $F_B(i)=j$ if $s_i=b_j$) and mapping functions are monotone strictly increasing (Hirschberg, 1977). It is then easy to compute the similarity between two strings directly related with the length of LCS. The degree of similarity is increasing with the length of LCS.

The following measure proposed by Vlachos et al. (2002) is used to adopt LCS for real valued time series. Given an integer δ and a real number $0<\in<1$, the distance, $D_{\delta,\in}$, between to time series A and B with lengths of m and n respectively is defined as:

$$D_{\delta,\in}(A,B)=1-\frac{LCS_{\delta,\in}(A,B)}{\min(m,n)} \tag{3}$$

where

$$LCS_{\delta,\in}(A,B)=\begin{cases}0 & \text{if } A \text{ or } B \text{ is empty}\\ 1+LCS_{\delta,\in}(Head(A),Head(B)) & \text{if } |a_n-b_m|<\in \text{ and } |n-m|\le\delta\\ \max\left(LCS_{\delta,\in}(Head(A),B),LCS_{\delta,\in}(A,Head(B))\right) & \text{otherwise}\end{cases}$$

and $Head(A)=(a_1,a_2,\ldots,a_{n-1})$, $Head(B)=(b_1,b_2,\ldots,b_{m-1})$, $D_{\delta,\in}\in[0,1]$ where values close to zero mean more similar series. If two series have no common patterns, the distance value is calculated as one and if two series are exactly equal or one time series contain exactly the other then this value is calculated as zero. In this setting there are two parameters to be set before measuring the similarity as a distance. These are integer δ which controls lag/lead time and a real number ∈ where the values are treated as very close if the absolute value of difference between them is less than this value.

The parameters of LCS are set to proper values in this analysis. The ∈ is set to inter-quantile range with quantiles which are 60th and 40th percentiles (Özkan and Erden, 2012). The width of rolling window is set to 96 months to include the commonly accepted longest period of business cycles. LCS parameter δ which controls lag/lead time is set to 12 months (or plus minus one year). With this setting, it is assumed that the transmission takes place within 12 months and the two series have around 20% similar values tagged as equal values in each rolling window. Since the upper limit of the period for business cycles is defined as 96 months, rolling window width is set to this value.

2.4. Analysis of transmission channels

Business cycle transmission channels are analyzed through panel regression models. The dependent variable is the degree of transmission that is obtained with an application of LCS algorithm. LCS measure is employed to rolling window of Turkish and other country's business cycle series to obtain the degree of transmission as the similarity of trajectories.

Degree of transmission is calculated as the distance between two series given in Eq. (3) and can be restated as:

$$TD_{TR-J,w}=D_{\delta,\in}(TR,J|w) \tag{4}$$

where $TD_{TR-J,w}$ is the transmission degree between *Turkish* and *J*th country for window *w*.

As for the transmission channels, several factors put forward in the related literature are considered, such as bilateral trade intensity, trade structure, financial integration measures, and monetary policy variables. One can refer to Frankel and Rose (1998), Shin and Wang (2004), Baxter and Kouparitsas (2005), Kalemli-Özcan et al. (2009) and Flood and Rose (2010) for details. Accordingly in our analysis we consider the following model:

$$\begin{aligned}TD_{TR-J,t}=&\beta_0+\beta_1BT_{TR-J,t}+\beta_2ISS_{TR-J,t}+\beta_3TSC_{TR-J,t}+\beta_4SHARE_{TR-J,t}\\&+\beta_5FDI_{TR-J,t}\,\beta_6INTRATE_{TR-J,t}+\beta_7DUMCUST_{TR-J,t}+\varepsilon_J\\&+\mu_t+u_{TR-J,t}\end{aligned} \tag{5}$$

where, $BT_{TR-J,t}$ denotes bilateral trade intensity, $ISS_{TR-J,t}$ industrial similarity, $TSC_{TR-J,t}$ trade similarity, $FDI_{TR-J,t}$ bilateral foreign direct investment intensity, $SHARE_{TR-J,t}$ similarity of stock market indices, $INTRATE_{TR-J,t}$ similarity of short term interest rates and $DUMCUST_{TR-J,t}$ is a dichotomous variable that takes a value of one if the country is a member of European Custom Union, EC. Thus, *BT*, *ISS*, *TSC* and *DUMCUST* are the variables that represent trade channel, *FDI* and *SHARE* control for financial integration and *INTRATE* represents monetary policy similarity[1]. The definitions of these variables are presented in Appendix A.

[1] Since fiscal policy coordination is considered an important channel, we use a measure for public debt similarities to account for this channel. However this variable does not contribute to the explanatory power of the model.

Table 1
Estimated smoothing parameter values for countries' IP series.

Country	Smoother	Country	Smoother	Country	Smoother	Country	Smoother
Austria	1.255	Germany	2.567	Luxemburg	1.469	Spain	3.527
Belgium	5.251	Greece	15.543	Mexico	1.7	Sweden	0.719
Canada	1.155	Hungary	27.82	Netherland	43.362	Turkey	1.756
Chile	2.197	Ireland	4.271	Norway	2.224	UK	0.963
Czech R.	3.319	İsrael	3.077	Poland	3.921	USA	0.557
Denmark	0.891	Italy	3.504	Portugal	5.374	Brazil	1.658
Finland	0.798	Japan	2.46	Slovakia	0.795	India	2.149
France	0.795	S. Korea	0.456	Slovenia	1.732	Russia	0.576

3. Data and results

This section includes three parts. The first two parts discuss the measurement of degree of transmission and transmission channel variables. The last part presents the results from the estimation of panel regression (5).

3.1. Data for degrees of transmission

OECD countries excluding Iceland, Australia, New Zealand, Estonia and BRIC countries except China are included in this analysis. Iceland, Australia, New Zealand, Estonia and China are excluded due to the unavailability of sufficient data on industrial production index. Hence the sample covers 32 countries together with Turkey. IP data are obtained through OECD stat database for business cycle measurement. The data on IP for most of the countries (Austria, Belgium, Canada, Chile, Finland, France, Germany, Greece, Italy, Japan, Luxemburg, Netherland, Norway, Portugal, Sweden, UK, and USA) cover the period between 1961 and 2010 while those for some countries including Turkey cover different time spans. For example, the data on IP for Indonesia, Russia, Chile, South Korea, Slovenia, Slovakia and Israel span from 1989 to 2010.

In the first step, in order to obtain the business cycles of the countries in the sample, IP data are HP-filtered with optimal smoother, then detrended with an assumption that they have linear trend. Table 1 shows the optimal smoother values calculated for each country. As it can be seen from the table, values are between 0.456 and 43.362.

In the second step, LCS algorithm is applied to the pairs of business cycles of Turkey and other countries in order to obtain the degree of business cycle transmission. Fig. 1 shows the LCS measure of transmission across time. It can be observed that the degree of transmission is increasing with time. The 95% confidence interval reveals that while the mean of transmission increases the variance of transmission decreases through time. It may indicate that the channels of transmission operate more efficient and robust in time[2]. In what follows, the study will use the LCS measure of transmission as the dependent variable in a panel regression. To do so, the data on potential independent variables (transmission channels) should be introduced first.

3.2. Data on transmission channels

BT, ISS, TSC and FDI series are obtained from OECD STAN database. SHARE, INTRATE series are obtained through OECD Stat database. Due to unavailability of data, we restrict the time dimension of panel data to 1998–2009 with 22 countries including Turkey. Table 2 shows the descriptive statistics of the variables of interest.

The independent variables used in our model are defined in Section 3.3 and explained in detail in Appendix A.

[2] We also calculate the mean degree of transmission using all rolling windows for country pairs. They appeared to be within the range of 0.55 and 0.70 except for few countries. There seems to be a significant variation in degree of transmission across country pairs.

3.3. Results from analysis of transmission channels

To this end, the regression model (5) is estimated using various panel estimation methods in order to see the sensitivity of the results to estimation techniques. The results are reported in Table 3. Before interpreting the results, we need to point out several econometric issues involved with the specification that are identified in the related literature. Especially, the previous studies rightfully point out the possibility of reverse causality in this regression. Accordingly, in Eq. (5), all variables except DUMCUST are likely to be simultaneously determined. Since Turkey entered into the custom union in 1996 which is before the sample periods of 1998–2009, the decision on joining into the union is not based on the correlation of business cycles.

The first and second columns of the table present the results from fixed effect estimation while the second column considers the first lags of the regressors in an effort to address the simultaneity issue at least in temporal sense. These columns provide a rough idea on the partial correlations between the dependent and independent variables. The third column shows the results from estimating the regression with the instrumental variable (IV) technique in an effort to overcome the endogeneity problem more seriously. The instrumental variables used in this study are the second lags of the regressors except for DUMCUST along with those based on the gravity equation such as GDP volumes of the country pairs, GDP similarity, distance and oil prices that control for the effects of common shocks[3]. The last column documents the results from GMM estimation method that extends the model to dynamic panel specification in which the lagged dependent variable is added to the model as a regressor. This method allows for both addressing the reverse causality problem and taking into account of a potential persistence in the dependent variable that is not controlled by the independent variables at hand. The same instruments are employed in the GMM estimation. Taken as a whole, the results are clearly sensitive to the estimation methods employed. Only is DUMCUST variable significant across all estimation techniques. This suggests that a preferred specification be identified based on the diagnostic tests in order to interpret the practical meanings of the results.

The first two columns are not chosen not only because they do not take a serious measure for endogeneity bias but also because there seems to be a first order autocorrelation problem in their errors as indicated by S.C.1 statistics of 19.3 and 14.2 respectively. The last column addresses the endogeneity problem and introduces dynamics to the model. However since the lagged dependent variable does not enter the model significantly, it is not preferred. The third column appears to be an appropriate specification since it takes the reverse causality seriously and performs well as evident from the diagnostic tests. A closer look at the results in the third column indicates the absence of the first and second order autocorrelation problems and optimality of the instruments as suggested by the J-test statistic of

[3] The data sources and definition of the instrumental variables are presented in Appendix B.

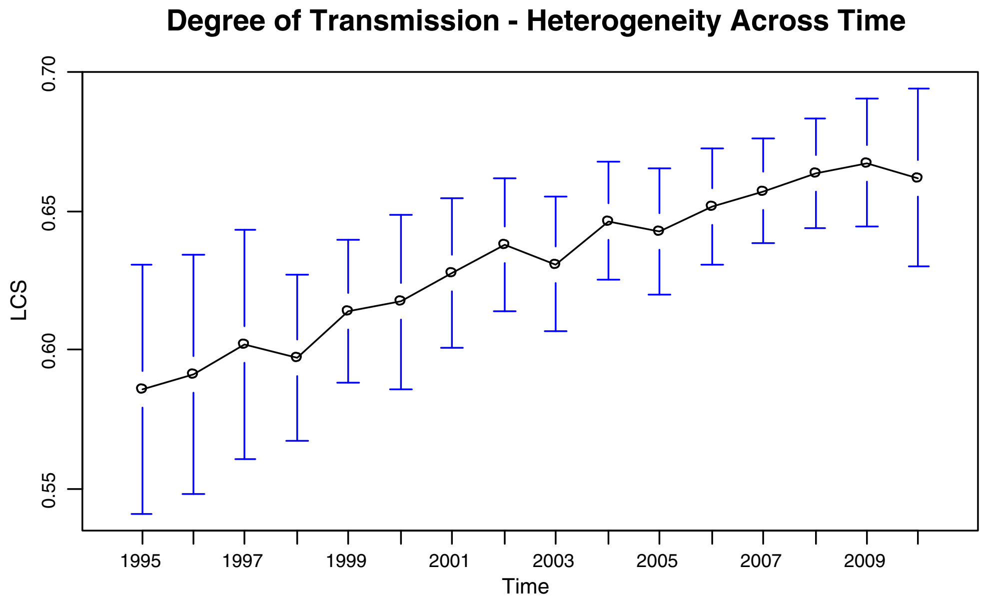

Fig. 1. Degree of transmission (measured with LCS) across time.

1.02. For these reasons the third column is chosen as the preferred specification and thus only the results from the IV estimation are interpreted practically.

As seen from the adjusted-R^2 of 0.67, the explanatory power of the model is quite high. While the variables BT, ISS, INTRATE and FDI are not significantly associated with business cycle transmission, the coefficients of TSC, SHARE and DUMCUST are significant and positive. The findings related to the role of international trade suggest that, rather than the volume of trade, the similarity of trade structures plays a significant role as a transmission channel, a result that supports the findings of the study by Shin and Wang (2004). This suggests that as Turkey becomes more of a part of vertically integrated trade structure, interdependency of its business cycles with the rest of the world is more likely to increase[4]. Furthermore, a rise in Turkey's financial integration as indicated by the similarity of the share prices (stock markets) appears to have a positive impact on the interdependencies of the business cycles. This result is in line with majority of previous studies focusing on the effect of financial integration. Another interesting result is about the role of European Custom Union in the transmission of international business cycles to Turkey, which suggests that a shock in the member(s) of the union is likely to be transmitted to Turkish economy.

4. Conclusion

Business cycle interdependency is becoming an important area of research since the process of globalization has been accelerated over the last decades. Sustainable long-run growth can be achievable by coupling an economy onto global economy during the expansionary period of global business cycle, while decoupling it during the global recession periods. In addition, developments in economic integration and currency areas make both academicians and authorities more interested in business cycle analyses, specifically in those analyses that shed light on the transmission channels of business cycles. Turkish economy has been in the process of integration with the world economies since the early 1980s. Hence, effectiveness of the transmission channels of economic shocks from world to Turkish economy is important for Turkish authorities in their policy decisions. Motivated by these considerations, this paper concentrates on the channels of transmission between Turkish and global business cycles.

Previous works on the subject employ MS-VAR, ST-VAR, and rolling window methods in order to address nonlinear and time-varying nature of business cycles. In addition, some empirical studies apply sophisticated statistical tools such as *coherence*, *cohesion*, *concordance* and *wavelet* analysis for measuring the degree of business cycle transmission. In this paper, a pattern recognition algorithm, Longest Common Subsequence, is used to measure the degree of transmission because LCS has properties that enable us to address both nonlinearity and time-varying property of business cycles. To the best of our knowledge, such an approach has not been conducted in this context.

To assess the channels of transmission; first LCS is employed to the business cycle pairs of Turkey and 31 other countries in the sample and then panel regression model is specified. The dependent variable of the regression is the degree of transmission and the explanatory variables are the variables that represent channels of transmission discussed in the literature. While similarities of trade and share prices and a dichotomous variable representing custom union membership are found to have positive and significant effects, bilateral trade intensity, similarities of industry structures and interest rates, and FDI intensity do not have significant effects on the transmission of business cycles from sampled countries to Turkey. The effect of trade similarity is not surprising. Previous studies pointed out that intra-industry trade is a channel through which business cycles become synchronized. As our calculations reveal that the trade similarity is increasing on average

Table 2
Descriptive statistics of variables.

	Min	Mean	Max
TD	0.3186	0.6334	0.7812
BT	0.0003	0.0093	0.0623
ISS	0.8761	0.9621	0.9911
TSC	0.1667	0.6132	0.9281
SHARE	0.1354	0.5931	0.8125
INTRATE	0.3542	0.6130	0.7292
FDI	−0.5191	0.0147	0.2868

[4] Our calculations show that the degree of trade similarity between Turkey and others are increasing on average over the sample period.

Table 3
Panel regression results.

	1	2 (First lags of the regressors)	3 (IV)	4 (GMM)
Constant	−0.262 (0.83)	0.448 (0.73)	−1.055 (0.59)	−5.386 (0.39)
BT	−6.760 (0.05)**	−3.211 (0.38)	−5.189 (0.41)	11.445 (0.47)
ISS	0.679 (0.58)	0.008 (0.99)	1.276 (0.54)	5.919 (0.33)
TSC	0.312 (0.005)***	0.071 (0.50)	0.289 (0.08)*	−0.330 (0.44)
SHARE	0.035 (0.75)	0.105 (0.23)	0.458 (0.003)***	−0.301 (0.14)
FDI	0.137 (0.37)	0.256 (0.08)*	0.249 (0.16)	0.779 (0.10)*
INTRATE	0.060 (0.25)	0.118 (0.16)	−0.052 (0.78)	0.026 (0.95)
DUMCUST	0.051 (0.000)***	0.037 (0.04)**	0.047 (0.08)*	0.018 (0.06)*
LSC_{t-1}				0.952 (0.18)
Adj-R^2	0.70	0.66	0.67	0.50
S.C.1	19.3*	14.2*	1.56	3.74
S.C.2	1.02	1.21	2.13	1.52
J-stat			1.02	0.55
Obs. (time*cross)	141 (10*21)	141(10*21)	94(8*17)	97(8*17)

Note: The figures in parentheses are the p-values corresponding to the t-statistics calculated by White's heteroskedasticity consistent standard errors.

with time, the transmission of global business cycles to Turkey can be expected to increase through this channel. Another result is that the financial integration represented by the similarity of stock market behavior appears to have positive impact on the interdependency between Turkish and world business cycles. This implies that the transmission of business cycles is expected to intensify with the process of financial integration. Finally it appears that there exists a positive effect of European Custom Union on the degree of business cycle transmission. In other words, Turkish business cycle is more likely to get a shock from the members of the custom union. The results of our study indicate that LCS is a measure that can be used for such complex phenomena and the results can be generalized by conducting a study using full country sample where country pairs are created to have all possible pairs. This more complete study is left for future work.

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Appendix A. Definitions of variables

Bilateral trade intensity:

$$BT_{TR-J,t} = \frac{x_{TR-J,t}+m_{TR-J,t}+x_{J-TR,t}+m_{J-TR,i}}{x_{TR,t}+m_{TR,t}+x_{J,t}+m_{J,t}}$$

where x_{TR-J} (m_{TR-J}) is Turkey's export (import) to (from) jth country, $x_{TR}(x_J)$ and m_{TR} (m_J) are Turkey's (Jth country's) total exports and imports respectively.

Industrial similarity measure:

$$ISS_{TR-J,t} = 1-\sum\nolimits_{n=1}^{N}(s_{TR-n,t}-s_{J-n,t})$$

where s_{TR-n} (s_{J-n}) are the shares of nth sector in Turkey's (jth country's) GDP when there are 9 sectors.

Trade similarity measure:

$$TSC_{TR-J,t} = \frac{\sum_{n=1}^{N} s_{TR-n,t}s_{J-n,t}}{\sqrt{\sum_{n=1}^{N} s_{TR-n,t}^2}\sqrt{\sum_{n=1}^{N} s_{J-n,t}^2}}$$

where s_{TR-n} (s_{J-n}) is the share of nth sector to the Turkey's (jth country's) total export (12 sectors)

Table 4
Descriptive statistics of instrumental variables.

	Min	Mean	Max
GDPVOL	21.0221	22.7279	24.7894
DISPERS	0.0268	0.3419	0.4952
OIL	14.4158	42.8144	99.5875

Bilateral FDI intensity:

$$FDI_{TR-J,t} = \frac{FDIin_{TR-J,t}+FDIout_{TR-J,t}+FDIin_{J-TR,t}+FDIout_{J-TR,t}}{FDIin_{TR,t}+FDIout_{TR,t}+FDIin_{J,t}+FDIout_{J,t}}$$

where *FDIin* (*FDIout*) is *FDI* in (out) as receiving (investing) country's records. Subscripts *TR-J* (*J-TR*) denotes between Turkey and *J*th country.

Share price similarity (*SHARE*):
This variable is obtained applying LCS algorithm to the pairs of stock market indices.

Interest rate similarity (*INTRATE*):
This variable is obtained applying LCS algorithm to the pairs of short term interest rates.

Appendix B. Data sources and definitions of instrumental variables

The instrumental variables employed for IV and GMM estimations are brent oil prices (*OIL*) to represent common shocks, the country size (*GDPVOL*), similarities of country sizes (*DISPERSE*) and distances between countries (*DISTANCE*) as gravity models suggest (Feenstra, 2004). Volume of country sizes is defined as $GDPVOL_{TR-J,t} = \log(GDP_{TR,t}) * \log(GDP_{J,t})$, similarities of country sizes as $DISPERSE_{TR-J,t} = 1-\left(\frac{GDP_{TR,t}}{GDP_{TR,t}+GDP_{J,t}}\right)^2-\left(\frac{GDP_{J,t}}{GDP_{TR,t}+GDP_{J,t}}\right)^2$ and distance between capital city of jth country and Turkey as $DISTANCE_{TR-J} = \log(DIST(C_{TR},C_J))$.

Data for the variables *OIL*, *DISTANCE* and real *GDP* are obtained from IMF-IFS, GEODIST and OECDstat databases respectively. Table 4 shows the descriptive statistics of instrumental variables.

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