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Global volatility accounting and structural transformation

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Abstract

This paper examines whether the modern phase of globalization that started in the mid-1980s altered the canonical result which emphasizes that macroeconomic volatility declines with development. The application of a framework that gives due consideration to comovements and structural transformation to a near-universe sample of economies at different stages of economic development suggests the following set of results. First, with an explicit account for the roles of structural transformation and comovements, macroeconomic volatility declines during the modern phase of globalization for the Centre while it increases for the Periphery. Second, macroeconomic volatility of the Periphery declines with development only where structural transformation is ruled out—an unrealistic situation. Third, comovements are found to be quantitatively important, albeit without altering the fact that structural transformation constitutes the primary vehicle of transmissions of volatility from the Centre to the Periphery, where China emerges as the epicentre.

JEL classifications: F44, F62, O11.

1. Introduction

The modern phase of globalization that started in the mid-1980s featured an extensive process of reallocation of resources from developed nations (the ‘Centre’) to developing nations (the ‘Periphery’) alongside a shift of resources across sectors within the economies of the Periphery. This process translated into a massive advance in real GDP per capita (in international prices) for the Centre and the Periphery for the periods 1970–1984 and 1985–2007 (a 55% and 36% average increase, respectively). Parallel to this development, the macroeconomic volatility of the Centre declined by 70% over the same periods—a startling contrast with the Periphery, where it increased by 90%.

This set of basic facts calls for the need to revisit the canonical result that macroeconomic volatility declines with development, which can be traced back to [Lucas \(1988\)](#) and was revived by the landmark contributions of [Acemoglu and Zilibotti \(1997\)](#) and [Koren and Tenreyro \(2013\)](#). An important empirical line of research initiated by [Koren and Tenreyro \(2007\)](#) tries to sort out the factors behind the decline of volatility with the level of economic

development. While this literature has contributed to the advancement of our knowledge, it has not given due consideration to the presence of the wide array of sectoral comovements that, along with massive structural transformation, reshaped the global economy over the four decades prior to the Great Recession. For example, the interplay between sectors within and between the economies of the Centre and the Periphery, tracked by comovements, has been considerably revamped, leading to a change in the contribution of production linkages in the origins of aggregate fluctuations, as well as the rise of the so-called decoupling of business cycle fluctuations between the Centre and the Periphery. These developments have significant implications for the patterns of global business cycle fluctuations, and yet they have not been given due consideration.¹

This paper contributes to the literature by shedding light on the following set of questions. First, what accounts for the striking difference in the levels of volatility between the Centre and the Periphery over the period 1970–2007? In particular, what is the quantitative importance of comovements, as opposed to variances, to the level of aggregate volatility? Second, as globalization gained traction during the period 1985–2007 and fuelled the advance of the level of real GDP per capita of the Centre and the Periphery, how did their macroeconomic volatility evolve, and what was the relative importance of variances and comovements? Similarly, how did the interplay between the Centre and the Periphery evolve? Third, did structural transformation represent an important vehicle for the transmission of volatility from the Centre to the Periphery?

To address these questions, I develop a simple accounting framework in Section 3 that accommodates the analysis of the level of volatility at one point in time, its change over time, and the underlying proximate sources. The framework is structured along two different, yet complementary, metrics.

The first metric features the notion of a ‘level’ similar to that used in the development accounting framework. It accommodates the decomposition of the variance of global real GDP growth into additive terms that track the proximate sources: the volatility levels of the Centre and of the Periphery, as well as the interplay (covariance) between these two blocs. Consider first the volatility that arises from each of these two blocs. It can be decomposed into two additive components. The first component is defined in terms of sectoral variances and is referred to as *direct effects*. It aggregates the idiosyncratic volatility that arises from each sector of the constituent economies of the bloc. The second component collects covariances (comovements) across sectors of the same economy and those between sectors of different economies within the same bloc. It is loosely defined as the *linkage effects*, as it tracks interconnectedness between sectors of economies within the same bloc. These linkage effects are, in turn, decomposable into *within-linkages* (across sectors of the same economy) and *between-linkages* (across sectors of different economies). The last building block of volatility of global real GDP growth, which aggregates the set of covariances that exists between sectors of the Centre and the Periphery, is referred to as *global linkage effects*. It

1 *The Economist* magazine, in its issue of 6 March 2008, offered the following metaphor of the notion of decoupling: ‘Perhaps the best support for decoupling comes from America itself. Fourth-quarter profits of big companies, such as Coca-Cola, IBM and DuPont, were better than expected as strong sales growth in emerging markets offset a sharp slowdown at home. In other words, bits of American business are rising above their own economy. With luck, the world economy can rise above America’s.’

tracks the extent of interconnectedness between sectors of the Centre and those of the Periphery.²

The second metric features the notion of ‘growth’ that is utilized in the growth accounting framework. It tracks the extent to which structural transformation, together with the changes in the intrinsic volatilities (a complex interplay between the direct effects and the linkage effects), explains the variation in the volatility reported by the Centre and by the Periphery, and their corresponding linkage effects (referred to as global linkage effects).

Compared to the literature reviewed in Section 2, the framework employed in this paper is inherently an accounting exercise and does not identify the underlying shocks in the tradition initiated by Stockman (1988) and subsequently employed by a host of papers (see di Giovanni *et al.*, 2014 and the references therein). The aim of this paper is simply to document the quantitative importance of the variances and the covariances (referred to as direct effects and linkage effects, respectively) that may ultimately arise from macro or idiosyncratic shocks, or a combination of both. The presence of sizeable comovements may suggest that sectoral production moves together, as would be the case if aggregate shocks were the dominant source of fluctuations, or if sectoral shocks had large and rapid spillover effects. Sorting out the relative importance of these shocks requires a structural model that is considerably beyond the scope of this paper. The task of this paper is merely to organize all of the data ‘under one roof’, and to ask whether the patterns identified can plausibly be deemed consistent with established facts in the hope that performing certain counter-factuals can help to point to key driving factors.

Using a near-universe coverage of the global economy over the period 1970–2007 (described in the online Appendix), the results reported in Section 4 suggest the following answers to the three sets of research questions. First, during the period 1970–1984, the Centre reported a disproportionately larger level of volatility in comparison to the Periphery. The forces behind the level of volatility of the Centre and the Periphery are strikingly different: linkage effects for the Centre are indicative of a higher degree of integration across the constituent economies than the level of integration within economies. This contrasts markedly with the Periphery, where weaker economic integration between the sectors of its economies and across its constituent economies gives precedence to direct effects. This suggests that, during this period, the primary sector that dominated the composition of the economy of the Periphery was prone to shocks. The modern phase of globalization, which covers the period 1985–2007, experienced a major reversal in the level of volatility—a sharp decline in the Centre contrasted with an immense increase in the Periphery. While, quantitatively, linkage effects remain relatively important in the Centre, they became the primary source of volatility in the Periphery—a reflection of an enhanced integration/diversification of the Periphery during this period that coincided with a substantial advance in the level of development.

Second, this contrasted evolution in the volatility of the Centre and the Periphery between these two periods, combined with a sharp advance in their respective levels of

2 I use a variant of the terminology proposed by di Giovanni *et al.* (2014). Using French microdata over the period 1990–2007, they found that, among other things, linkage effects are roughly three times as important as the direct effects in driving aggregate fluctuations. My framework accommodates the analysis of the quantitative importance of direct effects versus linkage effects on a global scale not only by level of development, but also the way in which they have evolved over time.

development (by 55% and 36%), suggests that the canonical result which emphasizes that volatility declines with the level of development needs to be nuanced, as it holds for the Centre but not for the Periphery. Third, the decline in the macroeconomic volatility of the Centre is primarily attributable to intrinsic volatility—a combination between the direct effects and the linkage effects—leaving little room for structural transformation. In contrast, structural transformation appears to be entirely responsible for the increase in macroeconomic volatility in the Periphery where, ultimately, China emerges as the epicentre.

The remainder of the paper is organized as follows. Section 2 reviews the literature and sketches where this paper fits in. Section 3 presents the accounting framework, while the empirical results are analysed in Section 4. Section 5 summarizes the findings and offers a possible avenue for future research. The source data, along with the underlying data, are available in the [online Appendix](#).

2. Related literature

This paper speaks to a wide range of contributions to the literature on macroeconomic volatility. A large strand of literature placed the emphasis on volatility of employment in relation to the changing structures of the global economy (e.g. [Bergin et al., 2009](#) and [Kurz and Senses, 2016](#), for a more recent treatment).³ A potential problem that may arise from this approach is the interpretation of the increase in volatility as a genuine phenomenon when, in fact, it may be driven by the declining importance of employment in agriculture and manufacturing. The concept of the volatility of real value added that is used in this paper eases the likelihood of this potentially misleading occurrence. The advantage of real value added is that it accounts for productivity gains that have been significant, particularly for developed economies (see [Rodrik, 2016](#), for a discussion).

The closest antecedent to this paper are the variance decompositions employed by [Karadimitropoulou and León-Ledesma \(2013\)](#) that rest on the application of a dynamic factor model to sectoral data to the G7 economies. [Karadimitropoulou \(2018\)](#) extended the analysis to a larger sample of economies at different levels of development.⁴ The variance of the sectoral output is decomposed into: (i) a global factor that picks up fluctuations that are common across all variables and countries; (ii) three group-specific factors that capture fluctuations that are common to all variables and all countries within each group of countries; (iii) country factors that are common across all aggregates in a given country; and (iv) idiosyncratic factors specific to each time series. Another way in which these contributions are relevant to my study is to quantify of the extent to which the changes in the sectoral variances result from within-effects, structural transformation, and the

- 3 While beyond the scope of the present paper—albeit still part of the aggregate volatility literature—it is important to highlight the existence of an impressive strand of literature that seeks to trace the business cycle fluctuations to the changing structures of the labour and product markets. Examples of this literature include [Thomas and Zanetti \(2009\)](#), [Campolmi and Faia \(2011\)](#), and [Zanetti \(2011\)](#), who placed the emphasis on the effect of labour market reforms on output and inflation volatilities. Building on [Zanetti \(2009\)](#), [Cacciatore and Fiori \(2016\)](#) extended this literature to encompass the joint effect of product and labour market regulation on volatility.
- 4 Recently, [Ardelean et al. \(2017\)](#) have extended this framework to accommodate the effects of trade and exposure to international markets. In this review, we abstract from the literature that brings trade to the fore.

interaction effect. While structural transformation is found to contribute only modestly in [Karadimitropoulou and León-Ledesma \(2013\)](#), leaving much of the impact to within-effects across all of the factors considered in the model, it is considered by [Karadimitropoulou \(2018\)](#) to be an important vehicle for more synchronized business cycle fluctuations at the regional and international levels.

My work also shares common features with [Koren and Tenreyro \(2007\)](#), who developed a decomposition of an economy's aggregate volatility into idiosyncratic sectoral shocks, aggregate country-specific shocks (shocks common to all sectors in a given country), and their covariance. The application of a factor model to a set of economies at different stages of economic development suggests that these types of shocks are important in shaping the patterns of aggregate volatility, and that they evolve differently over the process of structural transformation. Economies at the early stage of development possess an economic structure prone to idiosyncratic and macroeconomic shocks. While the relative importance of these shocks declines with development, their covariance does not entertain any specific pattern during this process; neither does it account for a relatively large share of their variance.

My work also relates to [Moro \(2015\)](#), who attributed the Great Moderation experienced by the US economy since the early 1980s to the process of structural transformation that features large-scale sectoral reallocations of resources, leading to a gradual fall in the relative size of the agricultural sector and a corresponding rise in manufacturing. As income continues to grow, services eventually emerge as the largest sector in the economy—a sector that also happens to report milder fluctuations.

This paper is also related in spirit to [Moro \(2012\)](#), who, in a two-sector general equilibrium model, found that structural transformation can account for close to 28% of the Great Moderation experienced by the US economy since the early 1980s. This result is due to the expansion of services that happen to report milder fluctuations, given their low-intensive use of intermediate inputs. In the same vein, within a calibrated two-sector general equilibrium model, [Da-Rocha and Restuccia \(2006\)](#) examined the interplay between structural transformation and business cycle fluctuations. Their result suggests that, as economies proceed with their structural transformation, cross-country business cycle fluctuations tend to converge.

Compared to this literature, my study presents some important differences that seek fresh insights into the recent developments of global business cycle fluctuations. Besides the set of idiosyncratic volatilities, my global volatility accounting framework identifies a variety of comovements that are spelled out in a parsimonious way to track the extent of complementarities across sectors of the same economy, across those of different economies within the same bloc, and between the Centre and the Periphery. In contrast, owing to the assumption of orthogonal factors, the variance decompositions utilized by [Karadimitropoulou and León-Ledesma \(2013\)](#) and [Karadimitropoulou \(2018\)](#) leave no room for comovements and rest on an econometric specification that requires some assumptions regarding its identification. Compared to the results reported by [Koren and Tenreyro \(2007\)](#), which downplay the role of comovements, my findings highlight their sizeable quantitative importance. My results stress the fact that, as the Periphery undergoes the dual process of structural transformation, there is no guarantee that this translates into a shift towards a less volatile production structure. The reduction in the macroeconomic volatility made possible by the intensive margin of structural transformation (i.e. away from the primary sector within a given economy), and emphasized by [Koren and Tenreyro](#)

(2007), can be mitigated by the increase of volatility triggered by the extensive margin of structural transformation (i.e. away from the Centre to the Periphery).⁵

My study may also be considered as an extension of Moro (2012) on the grounds that it offers larger coverage of developed economies above and beyond the USA and, more importantly, it not only accounts for the contribution of structural transformation to the Great Moderation, but also points to the remaining contributing factors. In all, though, despite the differences in coverage and the method, my results extend his findings on the modest role of structural transformation to the whole Centre. Compared to the competing literature on convergence and decoupling of business cycle fluctuations between the Centre and the Periphery highlighted by Da-Rocha and Restuccia (2006) and Kose *et al.* (2012), respectively, my results speak favourably to the latter. With an emphasis on the dual track of structural transformation (from the Centre to the Periphery and within the Periphery), my work also relates to the nascent literature on the transmission of business cycle fluctuations between developed and developing economies, particularly featuring the role of technology either in the form of its diffusion (Comin *et al.*, 2014) or its organization through production sharing (Bergin *et al.*, 2009).

My paper also contributes to the vast literature pioneered by Krugman and Venables (1995) and Venables (1996) on the geography of the industry location in the core-periphery and its impact on development. This literature emphasized the presence of linkage effects that favour agglomeration of industries that remain clustered within a single economy, and has been effectively utilized by Baldwin (2016) in his reading of the way globalization unfolded over the last two centuries. These linkage effects are the source of the important externalities that compensate for higher wage costs. As the economy of the Centre proceeds with structural transformation, wages experience an upward pressure that impedes the externalities that arise from linkage effects. At that point, firms have an incentive to deploy their activities to a low-wage country. While my paper conforms to this characterization, it contributes to this literature by highlighting the role of volatility and its transmission as economic activities are deployed across economies at different stages of development.

3. Framework

This section lays out the volatility accounting framework intended to identify the factors underlying the level of global volatility over a specific period and those driving its change over time.

The first metric features the notion of a 'level' similar to that used in the development accounting framework. It stresses the apportionment of global volatility into three additive layers: the Centre, the Periphery, and their comovements. The volatility that arises from the Centre and the Periphery is further decomposed into two additive components: *direct effects* and *linkage effects*. The direct effects component collects the series of volatility from each sector of the various economies constituent of a particular bloc; the linkage effects component combines *within-linkage effects* and *between-linkage effects*. Within-linkage effects track the comovements that exist between sectors of each of the constituent

5 The intensive process of structural transformation refers to the deployment of resources across activities within an economy, while its extensive counterpart refers to the deployment of resources from developed to developing economies. Section 4.1 provides more information on this topic.

economies of each bloc. In contrast, between-linkage effects measure comovements that prevail between sectors of the different economies constituent of each bloc. The third layer of global volatility, measured by the covariance terms between the Centre and the Periphery, quantifies the intensity and the direction of linkages that exist between these two blocs and is referred to as *global linkage effects*.

The second metric features the notion of ‘growth’ that is utilized in the growth accounting framework. It tracks how much structural transformation, together with the changes in intrinsic volatilities (a complex interplay between direct effects and linkage effects), explains the variation in the volatility reported by the Centre and the Periphery, and their corresponding linkage effects, referred to as global linkage effects.

3.1 Volatility level accounting

The global real GDP level in time t , denoted as Y_t , originates from two blocs: the Centre, Y_{Ct} , and the Periphery, Y_{Pt} . The annual growth rate of global real GDP can then be expressed as the weighted sum of real GDP growth of the constituent blocs:

$$\Delta \ln Y_t = \sum_b \bar{\pi}_{bt} \Delta \ln Y_{bt} \quad (1)$$

where $\bar{\pi}_{bt}$ is a two-period average share of the nominal GDP of the bloc b ($= C, P$) in the global nominal GDP, and Δ represents a first difference operator. Consider y_{bjt} as the level of real GDP of country j located in bloc b . Its annual growth rate can then be expressed as the weighted sum of real GDP growth of its j constituent economies:

$$\Delta \ln Y_{bt} = \sum_j \bar{\omega}_{bjt} \Delta \ln y_{bjt} \quad (2)$$

where $\bar{\omega}_{bjt}$ is a two-period average share of the nominal GDP of economy j in the nominal GDP of bloc b .

Assume that the economic activity of each economy j is structured along three main sectors: primary, p ; industry, i ; and services, s . The advance of its real GDP results from the weighted sum of real value added of its constituent sectors, with $\bar{v}_{bjkt}$ being a two-period average share of nominal value added of sector $k = p, i, s$ in the whole economy's j nominal GDP located in bloc b :⁶

$$\Delta \ln y_{bjt} = \sum_k \bar{v}_{bjkt} \Delta \ln y_{bjkt} \quad (3)$$

The combination of (1)–(3), presented in Equation (4) yields the decomposition of global real GDP growth along blocs, their constituent economies, and their related economic activities:

$$\Delta \ln Y_t = \sum_b \sum_j \sum_k \bar{\alpha}_{bjkt} \Delta \ln y_{bjkt} \quad (4)$$

with $\bar{\alpha}_{bjkt} = \bar{\pi}_{bt} \bar{\omega}_{bjt} \bar{v}_{bjkt}$ being the two-period average share of nominal value added of sector k in global nominal GDP. Using Equation (4), the level of volatility of the

6 This represents one of the three measures commonly used to track structural transformation. See Herrendorf *et al.* (2014, p.859), for a thorough discussion.

global real GDP growth (hereafter ‘global volatility’) can then be expressed as shown in Equation (5):

$$\begin{aligned} \text{Var}(\Delta \ell n Y_t) &= \text{Var}\left(\sum_b \sum_j \sum_k \bar{\alpha}_{bjkt} \Delta \ell n y_{bjkt}\right) \\ &= \sum_b \sum_{b'} \sum_j \sum_{j'} \sum_k \sum_{k'} \bar{\alpha}_{b'j'k't} \bar{\alpha}_{bjkt} \text{Cov}(\Delta \ell n y_{b'j'k't}, \Delta \ell n y_{bjkt}) \end{aligned} \quad (5)$$

Equation (5), which may be interpreted as an extension of the equations employed by di Giovanni and Levchenko (2009) and Comin and Mulani (2006) in a different setting, allows for the apportionment of the level of global volatility into two main building blocks: (i) volatility that arises from each bloc (b and b'), and (ii) co-movements between blocs ($b \neq b'$). The volatility that arises from each bloc can, in turn, be traced to two sources: the direct effects ($k = k', j = j', b = b'$); and the linkage effects comprising the within-linkage effects ($k \neq k', j = j', b = b'$), and the between-linkage effects ($k \neq k', j \neq j', b = b'$) and ($k = k', j \neq j', b = b'$). This decomposition of global volatility can be easily extended to accommodate the presence of more than two blocs or, even more realistically, the fragmentation of each bloc into various geographical areas. The latter exercise will be pursued later in this paper without, however, making this framework more burdensome than necessary.

3.2 Accounting for the volatility change

From the level of volatility accounting, I now turn to the sources underlying its changes over time. The changes to the level of global volatility can be traced to two components: structural transformation, modelled as the change in the share of nominal value added of each sector in the total nominal value added of the global economy ($\Delta \bar{\alpha}_{bjkt}, \Delta \bar{\alpha}_{b'j'k't}$); and changes in the intrinsic volatility, which encompasses the changes in the series of direct effects and linkage effects ($\text{Cov}(\Delta \ell n y_{b'j'k't}, \Delta \ell n y_{bjkt})$). Using Equation (5), the sources of global volatility change can be expressed as shown in Equation (6):

$$\begin{aligned} \Delta \text{Var}(\Delta \ell n Y_t) &= \Delta \sum_b \sum_{b'} \sum_j \sum_{j'} \sum_k \sum_{k'} \bar{\alpha}_{bjkt} \bar{\alpha}_{b'j'k't} \text{Cov}(\Delta \ell n y_{b'j'k't}, \Delta \ell n y_{bjkt}) \\ &= \sum_b \sum_{b'} \sum_j \sum_{j'} \sum_k \sum_{k'} \Delta \bar{\alpha}_{b'j'k't} [\bar{\alpha}_{bjkt} \text{Cov}(\Delta \ell n y_{b'j'k't}, \Delta \ell n y_{bjkt})] \\ &\quad + \sum_b \sum_{b'} \sum_j \sum_{j'} \sum_k \sum_{k'} \Delta \bar{\alpha}_{bjkt} [\bar{\alpha}_{b'j'k't} \text{Cov}(\Delta \ell n y_{b'j'k't}, \Delta \ell n y_{bjkt})] \\ &\quad + \sum_b \sum_{b'} \sum_j \sum_{j'} \sum_k \sum_{k'} \Delta \text{Cov}(\Delta \ell n y_{b'j'k't}, \Delta \ell n y_{bjkt}) [\bar{\alpha}_{bjkt} \bar{\alpha}_{b'j'k't}] \end{aligned} \quad (6)$$

The first and the second terms following the second equality sign from the top jointly represent the change in global volatility caused by the structural transformation, while the third term constitutes the change in global volatility attributed to the changes in the intrinsic volatility.

4. Empirical results

The main results are structured along five stylized facts, each of which is supplemented with a detailed analysis.

4.1 Structural transformation and volatility: some basic facts

Fact 1 The global economy experienced a dual track process of structural transformation. One track, affecting close to the combined size of the UK and Dutch economies (mainly their primarily manufacturing and services) was deployed from the Centre to the Periphery for the periods 1970–1984 and 1985–2007. The second track involved the Periphery initiating a massive process of structural transformation away from agriculture to manufacturing and services. This development was beneficial to both the Centre and the Periphery, which experienced an advance in their standard of living. At the same time, the volatility of the Centre declined while that of the Periphery increased. This fact reiterates one established result of the literature: globalization manifested itself through a dual track of structural transformation that led to an advance in terms of the standard of living for both the Centre and the Periphery. It also highlights a novel finding: this advance translated into a different outcome in terms of volatility—a decline of volatility in the Centre contrasted with its increase in the Periphery.

I begin by laying out some of the most important facts experienced by the Centre and the Periphery for the periods 1970–1984 and 1985–2007.⁷ These include a major shift in structural transformation that manifested itself through a deployment of resources from the Centre to the Periphery and across sectors within the economies of each of these two blocs.⁸ I then examine whether this set of shifts translated into an advance in terms of real GDP per person for both the Centre and the Periphery, and whether the way in which volatility reported by each of these blocs has evolved.

During the period 1985–2007, which gave rise to the modern phase of globalization, the global economy experienced a massive process of structural transformation featuring extensive and an intensive margins. The extensive margin represents the deployment of activities from the Centre to the Periphery, and the intensive margin highlights the shift within the Periphery of activities away from the primary sector towards industry and services. This dual track of structural transformation experienced by the global economy coincided with a development of the Periphery alongside an alteration in the macroeconomic volatility of these two blocs.

Figures 1 and 2 illustrate the extensive and intensive margins of structural transformation, respectively. Figure 1 indicates that, during the period 1985–2007, the Centre accounted for 72% of global nominal GDP (in PPPs), down from almost 79% during the period 1970–1984 to the benefit of the Periphery. The transfer of these seven percentage points of economic activity from the Centre to the Periphery may sound small but, when translated into absolute figures expressed in PPPs, they are equivalent to the whole

7 The post-1984 period is interpreted by a large body of literature reviewed by Čorić (2012) as an episode in which developed economies were marked by milder business cycle fluctuations. The exercise performed by Čorić (2012) for a sample of 84 countries at different levels of economic development suggests that the year 1984 represents a reasonable break point, for which 75% of the sample displays a reduction in volatility compared to an increase in volatility for the remaining 25%.

8 The dataset used in the implementation of our empirical framework results from the combination of a variety of source data maintained by the Groningen Growth and Development Centre. These are: the 10-Sector Database supplemented with the KLEMS database and the Productivity Level database, which compiles the 2005 benchmark value added PPPs for very broad sectors. The full description of the source data (including the dataset) is available in the [online Appendix](#).

Fig. 1. Extensive margin of structural transformation (percentage of global GDP).

Fig. 2. Intensive margin of structural transformation (percentage of global GDP).

economic activity generated by the UK and the Dutch economies combined during the period 1970–1984.

Figure 2 shows that the relative importance of sectors within the Centre did not change during the period 1985–2007 compared to the earlier period. This contrasts markedly with the Periphery, where significant reallocations happened in the meantime. These results

suggest that, by the early 1980s, the intensive margin of the process of structural transformation had, by and large, reached its completion in the Centre. The marginal changes experienced by the Centre during the period 1985–2007 can be attributed to the Periphery of this bloc, as represented by the economies of southern Europe such as Spain and Portugal (see Caselli and Tenreyro, 2006). Thus, the entire picture regarding the intensive margin of structural transformation during the period 1985–2007 concerns the Periphery.

Table 1 reports two valuable pieces of information for the periods 1970–1984 and 1985–2007: the growth in real GDP per capita (in PPPs) over these two periods for the Centre and the Periphery, and the corresponding change in macroeconomic volatility. Figures 1 and 2 combined with Table 1 convey an interesting tale. The dual process of structural transformation translated into a rapid growth of real GDP per capita of the Centre and the Periphery. This advance coincided with a decline in the macroeconomic volatility of the Centre, contrasted with an increase in that of the Periphery. Thus, the picture conveyed by Table 1 reverses the canonical negative relationship between volatility and level of development emphasized by the literature. These results beg for the factors that underlie the differences in the level of volatility between the Centre and the Periphery, and the question as to whether structural transformation is the key factor behind the increase in volatility of the Periphery.

4.2. An account for global volatility

4.2.1 Volatility level: centre versus periphery Fact 2 Considering the analysis of volatility on the basis of only the direct effects (hereafter ‘variance’) can be misleading, as linkage effects (hereafter ‘covariance’) are generally disproportionately larger. Isolating the direct effects (variance) from the linkage effects (covariances) sheds important light for understanding the sources of business cycle fluctuations. Under the hypothetical environment where the Centre is independent from the Periphery, the linkage effects ascribed to each bloc present the main story behind the level of volatility of the Centre during each of the periods 1970–1984 and 1985–2007. The story is more nuanced for the Periphery, where the linkage effects experienced a significant rebound during the period 1985–2007 following a period in which the direct effects were the primary force behind the volatility of this bloc. The change in the volatility over these periods 1970–1984 and 1985–2007 reiterates the presence of the Great Moderation for the Centre—a sharp contrast with the Periphery, where volatility increased. Whatever the pattern of volatility over the periods 1970–1984 and 1985–2007 for these two blocs, linkage effects dwarf the direct effects as a source of the change in volatility.

This section begins with an analysis of the level of volatility reported by the Centre and the Periphery during the periods 1970–1984 and 1985–2007, and quantifies the relative importance of the direct effects, and linkage effects (comprising within-linkage effects and between-linkage effects). Within-linkage effects quantify the importance of linkages across sectors of the same economy, while between-linkage effects focus on those that arise across sectors of different economies of the same bloc. At this stage, the linkages between the Centre and the Periphery are ruled out; however, they will be considered in Section 4.2.2. This is done in an effort to contrast my results with those of the literature on the Great Moderation, which emphasizes the role of direct volatility but ignores the role of comovements.

Panel A of Table 2 reports the aggregate level of volatility of the Centre during the periods under consideration. Of the 1.106 level of volatility reported by the Centre during the

Table 1. Development and volatility

	1970–1984		1985–2007		Change in %	
	Real GDP per capita	Level of volatility	Real GDP per capita	Level of volatility	Real GDP per capita	Volatility
Centre	21,861	1.100	33,935	0.330	55.2	–70.0
Periphery	4,415	0.080	6,012	0.154	36.2	90.1

Source: Penn World Tables, edition 9.0.

Note: Volatility is measured in terms of the variance of real GDP.

Table 2. Global volatility level and its sources

	1970–1984		1985–2007	
	Level	%	Level	%
A. Centre				
Aggregate volatility	1.106	100.0	0.328	100.0
Direct effects	0.334	30.2	0.130	39.6
Linkage effects	0.772	69.8	0.198	60.4
Within-linkages	0.320	28.9	0.120	36.6
Between-linkages	0.452	40.9	0.078	23.8
B. Periphery				
Aggregate volatility	0.081	100.0	0.154	100.0
Direct effects	0.054	66.7	0.056	36.4
Linkage effects	0.027	33.3	0.098	63.6
Within-linkages	0.046	56.8	0.055	35.7
Between-linkages	–0.019	–23.5	0.043	27.9

Notes: Direct effects track sectoral variances. Linkage effects track interconnectedness between sectors, and represent the sum of within- and between-linkages: within-linkages measure interconnectedness across sectors of the same economy, while between-linkages track interconnectedness across sectors of different economies. Volatility is measured in terms of the variance of real GDP.

period 1970–1984, 70% results from linkage effects, the bulk of which is accounted for by between-linkage effects (40 percentage points). The quantitatively important role of between-linkage effects is consistent with the notion advanced by Baldwin (2012) that the production system during that period was complex and thus needed to be maintained in close proximity to lower the cost of coordinating the complexity. The proximity of a complex integrated production system makes it possible for idiosyncratic shocks to make their way throughout the entire economies of this bloc. A competing explanation could be that sectors constituting economies of the Centre react in the same way to a common macroeconomic shock, thus creating strong linkage effects. Either way, this implies that sectors that possess a relatively large size of comovements indicate a high degree of complementarity that facilitates the propagation of the effects of shocks. My results suggest that, as much as this proximity generated benefits (reduction in the coordination costs), it possesses important costs that take the form of an important extent of volatility.

Also during the period 1970–1984, the Periphery reported a 0.081 level of volatility for which the direct effects are responsible for two-thirds—a startling contrast with the Centre (Table 2, Panel B). This result highlights the fact that, during this period, the economy of the Periphery was structured around the primary sector, which is disproportionately larger compared to other sectors and much more prone to shocks (see [Koren and Tenreyro, 2007](#)). The modest role of linkage effects, which account for the remaining one-third movement of volatility, is largely due to negative between-linkage effects. This suggests a lack of synchronization in the business cycle across the economies of the Periphery during this period, reflecting the absence of integration across economies of this bloc.

The period 1985–2007 features a complete reversal in the level of volatility in the Centre and the Periphery, together with underlying primary forces at work. The volatility of the Centre declined to 0.328, while that of the Periphery increased to 0.154. While the linkage effects remain important as a source volatility in the Centre (60%), between linkage effects shrank considerably (from 40 to 24 percentage points between the two periods). As for the Centre, the Periphery now has the linkage effects driving the bulk of its volatility (64%), a result that stems from between linkage effects that became positive during this period. The turnaround of the between-linkage effects constitutes the main story for the Periphery during the period 1985–2007, an indication that economies of this bloc have become more integrated, leading to more synchronized business cycle fluctuations along the way. Both the Centre and the Periphery now report a reasonably close convergence in the relative importance of the sources of business cycle fluctuations and, particularly, feature disproportionately large linkage effects, with a primary role for within-effects. This suggests that the close proximity of the production system of the Centre is no longer a requirement during this period as the development of information technology made it possible to maintain the complex system at a distance. With close proximity no longer being a requirement⁹ combined with favourable wage differences, the Centre initiated a massive process of deployment of activities to the Periphery. These activities, which had previously been performed in close proximity in the Centre, are now in the Periphery. The upshot of this development is a reduction in the relative size of between-linkage effects in the Centre to the benefit of those in the Periphery.¹⁰

While many of the results discussed above are novel, those related to the Centre over the period 1985–2007 can be contrasted with those obtained by [di Giovanni et al. \(2014\)](#) for France during the period 1990–2007. Although differences with respect to the approach and source data make a definitive reconciliation with my results impossible, some broad similarities and differences are worth highlighting. First, they found that linkage effects are about three times the size of the direct effects—considerably higher than the 1.5 obtained from Table 2, Panel A, for the period 1985–2007. Despite the fundamental differences between their approach and mine, and the order of magnitude of the estimates, the results nonetheless remain consistent, as they both highlight the disproportionately higher level of

9 In the words of [Baldwin \(2012, p.4\)](#), ‘the coordination glue began to melt’.

10 A further breakdown of Table 2, available in the [Appendix](#), indicates that, of the 0.452 accounted for by the between-linkage effects of the Centre during the period 1970–1984, 45% alone is due to the interplay across industries and across services. This proportion declined to 41% during the period 1985–2007 largely due to the interplay between industries, compensated partly by the interplay between services. During this period, the interplay between industries in the Periphery alone represents 45% of the between-linkages.

linkage effects. The value-added of the present paper is to emphasize that this ratio declined from 2.3 to 1.5 during the periods 1970–1984 and 1985–2007 in the Centre, and increased in the Periphery from 0.5 to 1.7—largely due to the between linkage effects.

4.2.2 Volatility level: the global perspective *Fact 3* Considering the global economy as a whole, the Centre was responsible for about three-quarters of global volatility during the period 1970–1984, leaving a mere 6% for the Periphery, and 20% for the global linkage effects between the Centre and the Periphery. The dual track of structural transformation that benefited the Periphery over the period 1985–2007 coincided with a major reversal. The Periphery is now responsible for a full one-quarter of global volatility, mainly to the detriment of the Centre. Global linkage effects receded during this period—an indication of the business cycle decoupling between the Centre of the Periphery. Linkage effects remain the primary force behind the level of global volatility and its change over time.

I now focus on an analysis of global business cycle fluctuations. The analysis rests on the absolute figures reported in Table 1 for each bloc, to which I append the order of magnitude of global linkage effects that arise from the comovements between the Centre and the Periphery. The results are reported in Fig. 3, which shows that, of the 1.467 level of global volatility during the period 1970–2004, 75.4% was attributable to the Centre and a mere 6% to the Periphery, leaving close to 20% to the global linkage effects between the Centre and the Periphery. The relative importance of linkage effects identified earlier for the Centre makes its way to the global economy, where it alone accounts for half of global volatility.

The period 1985–2007 features a number of changes ranging from a decline in the global volatility to 0.572 to the geographical allocation of global volatility, including the underlying forces. Though still the main source of global volatility with a 57.3% contribution, the relative importance of the Centre declined to the benefit of the Periphery, which is now responsible for 27%. Linkage effects continue to generate slightly more than half of the global business cycle fluctuations, partly as result of the Centre, which is responsible for one-third, but also the Periphery, which generates slightly less than one-fifth. Another important development during this period is a moderate decline to 16% in the relative importance of synchronicity in the fluctuations of business cycles between the Centre and the Periphery.

In summary, linkage effects of the Centre, together with global linkage effects between the Centre and the Periphery (which once were the primary source of global business cycle fluctuations) lost considerable steam to the sole benefit of the linkage effects within the Periphery. This set of results suggests an interesting tale. Progress in structural transformation during the period 1985–2007, which highlights deployment of activities from the Centre to the Periphery and the reallocation of resources across sectors within the Periphery, translated into a better integration across sectors not only within the economies of the Periphery, but also across economies of this bloc. This development translated into higher business cycle synchronization in the Periphery, which makes up for the short-fall in the synchronization within the Centre, as well as between the Centre and the Periphery.

Before proceeding to the analysis of the change in volatility in the periods 1970–1984 and 1985–2007, it is useful to compare the results that have just been presented with those reached by a recent strand of literature on global business cycle fluctuations and their underlying sources. For example, Kose *et al.* (2012) underscore the presence during the

Fig. 3. Sources of global business cycle fluctuations (percentage points).

period 1985–2005 of a convergence in business cycle fluctuations within the group of emerging market economies and within the group of industrial economies, contrasted with a divergence (or decoupling) between these two groups. Differences with respect to time period and methodology make a definitive reconciliation with my results impossible. For example, I rely on an accounting framework using sectoral data of a sample of 30 economies over the period 1970–2007 compared to the use by Kose *et al.* (2012) of a dynamic factor model applied to aggregate data of a larger sample of economies over the period 1960–2008. Nonetheless, it is useful to compare whether my findings are broadly consistent with theirs. Compared to the earlier period, the period 1985–2007 features the quantitative importance of linkage effects in each bloc, suggesting the presence of similar forces at work represented by linkage effects. The results also point to a moderation in the relative importance of global linkages, lending some support to the notion of decoupling in the business cycle fluctuations between the Centre and the Periphery. The consistency between my results and theirs suggests that this stylized fact seems to be robust to other methods and data sources.

4.2.3 Volatility change accounting 4.2.3.1 Basic patterns and roles of structural transformation versus intrinsic volatility. Fact 4 The forces behind the change in volatility in the periods 1970–1984 and 1985–2007 are different in the Centre from those in the Periphery. The increase in volatility reported by the Periphery is largely accounted for by structural transformation—a sharp contrast with the decline in volatility reported by the Centre, which is due to direct and linkage effects. The decline in global volatility is primarily due to the Centre, which is responsible for slightly more than four-fifths, with global linkage effects trailing far behind at about 20%. This contrasts markedly with the Periphery, which raises global volatility by about eight percentage points—all of which is the result of structural transformation.

I now move to the examination of the patterns underlying the changes in the volatility level during the periods 1970–2004 and 1985–2007, the goal being to quantify the contributions of structural transformation and intrinsic volatility in the way characterized by Equation (6). I begin with the order of magnitude of the changes in volatility of the Centre and the Periphery, and their linkages presented in Fig. 3, to which I append the percentage point contributions of structural transformation and intrinsic volatility.

The results of this exercise, which are reported in Fig. 4, suggest that the level of volatility of the Centre during the period 1985–2007 fell by 70% from its level in 1970–1984, of which 62 percentage points are attributable to intrinsic volatility. Structural transformation accounts for only 8.4 percentage points. Standing in sharp contrast to these broad patterns, the volatility of the Periphery increased by a hefty 90% (though from a low level), due almost entirely to structural transformation. Besides the significant difference in the order of magnitude, the contribution of structural transformation had an opposite effect on macro-economic volatility: it contributed to lifting volatility in the Periphery while dampening it in the Centre. I will come back to this result in due course.

It is instructive to place these results in the context of the so-called Great Moderation debate in developed nations investigated by abundant literature and surveyed by Davis and Kahn (2008). Several explanations have been advanced ranging from structural transformation to the occurrence of shocks with milder and short-lasting effects, including better stabilization policies. While sorting out the relative merits of these explanations is beyond the scope of this paper, my results certainly rule out the notion of structural transformation as a source of the Great Moderation experienced by developed nations. Moro (2012), for the USA, and Karadimitropoulou and León-Ledesma (2013), for the G7, have also reached the same conclusion—an indication that this result is robust to other methods and source data.

I now move to the question of how much the Centre and the Periphery, and their interplay, contributed to the decline of global volatility in the periods 1970–1984 and 1985–2007 from 1.467 to 0.572 (a 61% decline) (see Fig. 3). An interesting insight that can be gained from the answer to this question is whether there is any evidence of a shift in the contribution to global volatility away from the Centre to the Periphery, thus lending support to the notion that the massive deployment of activities from the Centre to the Periphery is accompanied by a commensurate volatility. Figure 5, which shows the extent to which each of the blocs and their linkages contribute to the global volatility, does just that. Of the 61% decline in global volatility, the Centre contributed 86%, compared to 21% for global linkages. In contrast, the Periphery mitigated this slide by pushing up global volatility with a modest 8% contribution. In terms of the contributing factors, the results suggest that the 11 percentage point contribution of structural transformation to the Great Moderation by the Centre has virtually been offset by a 9 percentage point contribution of this process to the increase in volatility in the Periphery. These patterns of structural transformation can be interpreted as having a virtually ‘zero-sum game’ effect in the transmission of fluctuations from the Centre to the Periphery.

4.2.3.2 Counter-factuals. Fact 5 The geography of volatility traces the increase of volatility observed for the Periphery during the periods 1970–1984 and 1985–2007 to Asia. All other continents of the Periphery, instead, experienced a decline in volatility. The conduct of a thought experiment that shuts down the occurrence of structural transformation leaves the results virtually unchanged except for Asia where volatility declines—thanks to the massive contribution by China. This result is consistent with the literature that documented the

Fig. 4. Role of structural transformation and intrinsic volatility in the changes of the primary building blocks of global volatility, 1970–1984 and 1985–2007 (percentage points).

Fig. 5. Contributions of the centre, periphery and their linkages to global business cycle fluctuations (percentage).

peculiar process of structural transformation in Africa and Latin America where resources have been shifted from agriculture to services, a sector that is typically less volatile than manufacturing. It also highlights the fact that the so-called ‘China shock’ goes beyond the impact on local labour markets in developed and developing economies, extending to the realm of global business cycle fluctuations where a decoupling between the Centre and the Periphery has occurred.

I now complete this quantitative analysis with a set of counter-factuals that ascertains the impact of structural transformation and the between-linkage effects on the nature of the

relation between macroeconomic volatility and development. Both of them represent an important vehicle of transmission of erratic business cycle fluctuations; thus, it is important to quantify their relative quantitative importance. Regarding structural transformation, I assume that the snapshot of the structures of the economy considered during the period 1970–1984 remain unchanged during the subsequent period. This assumption has a dual implication. First, it implies that the intensive margin process of structural transformation has been completed in the Centre, but has not quite been completed in the Periphery. Second, the extensive margin process of structural transformation from the Centre to the Periphery, which started during the second period considered in our analysis, has been assumed away. Similarly, the exercise rules out the quantitative importance of global linkage effects for the sake of simplicity.¹¹

The results reported in Table 3 provide an indication of the way in which macroeconomic volatility that can be estimated under other assumptions varies with an increase of development. Panel D reproduces the results reported in Table 2 and is considered the benchmark result. This panel contrasts the decline of volatility in the Centre with an increase of volatility in the Periphery in the presence of structural transformation and between linkage effects. This result still holds even if between-linkage effects are assumed away (Panel C). Volatility declines with development only in the absence of structural transformation (Panel B), while ruling out the presence of linkage effects does not change the story but simply magnifies the decline of volatility in the Periphery and moderately dampens that of the Centre (Panel A). Given the crucial role of structural transformation in the direction of the results, the remainder of these counter-factuals places the emphasis on its effect, while leaving intact the role of between-linkage effects.

Figure 6 compares the percentage changes in the volatility of the Centre and the Periphery, and their global linkage effects with and without an account for structural transformation. The figures with structural transformation have already been discussed in Fig. 5, but they are repeated here for reference purposes. Despite the absence of structural transformation, the Great Moderation remains robustly present in the Centre, reiterating the fact that intrinsic volatility is the primary force behind this stylized fact. In contrast, with a 22% decline in the volatility, the Periphery now reports a significant presence of the Great Moderation, thus corroborating the result that the dual track process of structural transformation is the entire story behind the macroeconomic volatility of this bloc.

In performing the counter-factuals, I still assume that the global economy is structured along the Centre, the Periphery, and their linkages. To gain more insights on the geographical sources of global volatility and how they have been altered without structural transformation, the Centre and the Periphery are fragmented into their main regional economies. Figure 7 is analogous to Fig. 6, except that it provides a regional breakdown, which highlights two messages. First, Asia is the only geographical source of increase of volatility reported by the Periphery, and is the primary beneficiary of the dual process of structural transformation. Second, much of the story behind Asia and global linkages is due to China—an indication that China's emergence as a major manufacturing powerhouse has

11 For this exercise, I ruled out the between-linkage effects. The motivation behind this is to try to make my results as directly comparable to those of the literature as possible (e.g. Koren and Tenreyro, 2007). In their paper, Koren and Tenreyro, 2007 consider the variance of each economy, which arguably comprises the variance and within-linkage effects.

Table 3. Macroeconomic volatility and development under alternate hypothesis

	1970–1984	1985–2007	Change in %
A. Without between-linkage effects and without structural transformation			
Centre	0.654	0.282	–56.9
Periphery	0.100	0.046	–54.0
B. With linkage effects and without structural transformation			
Centre	1.106	0.392	–64.6
Periphery	0.081	0.063	–22.2
C. Without between-linkage effects and with structural transformation			
Centre	0.654	0.250	–61.8
Periphery	0.100	0.111	11.0
D. With linkage effects and with structural transformation			
Centre	1.106	0.328	–70.3
Periphery	0.081	0.154	90.1

Note: Between these two periods, real GDP per person advanced from \$21,861 to \$34,501 (in international 2005 prices) in the Centre, compared to \$4,415 to \$5,704 in the Periphery, which represent respective growths of 58% and 29%. With the elimination of structural transformation during the second period, the growth is slightly higher in the Centre and slightly lower in the Periphery.

Fig. 6. Percentage changes in volatility: 1985–2007 versus 1970–1984.

Fig. 7. Percentage changes in volatility across major regions: 1985–2007 versus 1970–1984.

altered not only local labour markets, but also global business cycle fluctuations, which are now decoupled between the Centre and the Periphery (on local labour markets, see [Autor et al., 2016](#)).

5. Conclusion

This paper revisits the interplay between macroeconomic volatility and development, and highlights the role of linkage effects, and a dual process of structural transformation as a vehicle of transmission of business cycle fluctuations from the Centre to the Periphery. The accounting framework identifies the role of direct effects and three types of linkage effects—across-sectors within a given economy, across sectors between economies of a given bloc, and between sectors of economies of the Centre and the Periphery. There are three types of results based on a near-universe sample of economies at different stages of development over the period 1970–2007.

First, during the period 1970–1984, with close to a three-quarters contribution, linkage effects is the main story behind global volatility, the bulk of which arises from the Centre. The whole story of global business cycle fluctuations during this period revolves around the Centre and leaves virtually no room for the Periphery. The high degree of integration across sectors within economies and across economies constituent of the Centre represents a powerful vehicle of propagation of shocks that originate from this bloc.

Second, the period 1985–2007 experienced an important dual track process of structural transformation. The extensive margin stresses a reallocation of 7 percentage points of activities of the global economy from the Centre to the Periphery. The intensive margin of structural transformation occurred primarily within the Periphery, where 7 percentage points of resources have been shifted from the primary sector to industry and services. This development translated into a larger contribution by the Periphery to global fluctuations, mainly to the detriment of the Centre. The gaining of importance of the Periphery to global

fluctuations resulted primarily from the massive increase of its linkage effects—an indication that progress in structural transformation in the Periphery translated into a larger and better integration across sectors and economies of this bloc, making them prone to a propagation of shocks.

Third, the period 1985–2007 also features milder business cycle fluctuations of the global economy, a manifestation of the Great Moderation in the Centre and in the global linkages between the Centre and the Periphery. The Great Moderation reported by the Centre is largely attributable to intrinsic volatility, leaving a modest 12 percentage point contribution to structural transformation. This contrasts markedly with the Periphery, which reported a hefty increase in volatility, attributable almost entirely to structural transformation. The resulting Great Moderation of the global economy reflects the net effects of three forces: the Centre—which contributed 87% (of which 11 percentage points are attributable to structural transformation; 21% to global linkages; and 8.2% to the Periphery, of which 9.2 percentage points are due to structural transformation). The combination of these results suggests that, at the level of the global economy, virtually all of the contribution of structural transformation to the Great Moderation in the Centre has been offset by its counterpart in the Periphery. This implies that structural transformation is the primary vehicle for asymmetric business cycle fluctuations from the Centre to the Periphery. A series of counter-factuals corroborated this result. The result also lends some support to the notion of decoupling between the Centre and the Periphery during the period 1985–2007, owing largely to the better integration of economies of the Periphery.

How should we interpret these results? While structural transformation has been established by a well-established strand of literature as a powerful vehicle for development, it has been exploited to a relatively lesser extent to explain the transmission of business cycle fluctuations from the Centre to the Periphery. Extending the relevance of structural transformation (both intensive and extensive) to the realm of the transmission of international business cycle fluctuations may represent a fruitful future research agenda.

Supplementary material

[Supplementary material](#) is available on the OUP website. These are the data and replication files and the [online appendix](#).

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Appendix

Table A1. Global volatility level and its detailed sources

	Level	%	Level	%
A. Centre				
Aggregate volatility	1.106	100.0	0.328	100.0
<i>Direct effects</i>	0.334	30.2	0.130	39.6
Primary	0.086	25.7	0.043	33.1
Industry	0.187	56.0	0.032	24.6
Services	0.061	18.3	0.055	42.3
<i>Linkage effects</i>	0.772	69.8	0.198	60.4
Within-linkages	0.320	100.0	0.120	100.0
Primary-Industry	0.089	27.8	0.023	19.2
Primary-Services	0.098	30.6	0.029	24.2
Industry-Services	0.133	41.6	0.068	56.7
<i>Between-linkages</i>	0.452	100.0	0.078	100.0
Primary-Primary	0.078	17.3	0.012	15.4
Industry-Industry	0.107	23.7	0.014	17.9
Services-Services	0.097	21.5	0.018	23.1
Primary-Industry	0.034	7.5	0.004	5.1
Primary-Services	0.028	6.2	0.003	4.5
Industry-Services	0.108	23.9	0.027	34.0
B. Periphery				
Aggregate volatility	0.081	7.3	0.154	47.0
<i>Direct effects</i>	0.054	4.9	0.056	17.1
Primary	0.041	75.9	0.017	30.4
Industry	0.009	16.7	0.032	57.1
Services	0.004	7.4	0.007	12.5
<i>Linkage effects</i>	0.027	2.4	0.098	29.9
Within-linkages	0.046	100.0	0.055	100.0
Primary-Industry	0.028	60.9	0.029	52.7

(continued)

Table A1. Continued

	Level	%	Level	%
Primary-Services	0.014	30.4	0.019	34.9
Industry-Services	0.004	8.7	0.007	12.3
<i>Between-linkages</i>	-0.019	100.0	0.043	100.0
Primary-Primary	0.010	-63.2	0.006	14.2
Industry-Industry	-0.090	479.3	0.019	44.8
Services-Services	-0.010	63.2	0.009	21.3
Primary-Industry	-0.010	43.9	0.004	9.3
Primary-Services	0.000	11.2	0.003	8.1
Industry-Services	0.080	-434.5	0.001	2.2

Notes: Direct effects track sectoral variances. Linkage effects track interconnectedness between sectors, and represent the sum of within- and between-linkages: within-linkages measure interconnectedness across sectors of the same economy, while between-linkages track interconnectedness across sectors of different economies. Volatility is measured in terms of the variance of real GDP.