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Regional business cycle synchronization through expectations

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Abstract

This paper provides an example in which regional business cycles may synchronize via producers' expectations, even though there is no interregional trade, by means of a system of globally coupled, noninvertible maps. We concentrate on the dependence of the dynamics on a parameter η which denotes the inverse of price elasticity of demand. Simulation results show that several phases (the short transient, the complete asynchronous, the long transient and the intermediate transient) appear one after another as η increases. In the long transient phase, the intermittent clustering process with a long chaotic transient appears repeatedly.

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1. Introduction

A national economy consists of diverse regional sub-economies, and national business cycles are an admixture of regional cycles. One of the stylized facts about regional cycles is that fluctuations in different regions of a national economy are inclined to synchronize with each other [1–3].

One possible explanation of this synchronization may be that it occurs due to common exogenous shocks such as national fiscal and/or monetary policies, sudden changes in world commodity prices, fads among consumers, and so forth. However, several studies find that common shocks do not seem to be the cause of such synchronization [4,5].

Another possible explanation is that the synchronization is caused by trade linkages between different regions of the economy. A nonlinear mode-locking model is proposed as a mechanism[1] [7], taking into consideration the empirical evidence which suggests that the aggregation process of regional cycles might be

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[1]There are many studies applying a mode-locking mechanism to some other aspects of business cycles, which are surveyed briefly by Süssmuth [6].

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more adequately described by a nonlinear process than by a linear one [8]. Mode-locking is an inherently nonlinear linkage phenomenon; cycles of different elements are synchronized, i.e., attain 'mode-lock', when the strength of the linkage between oscillating elements reaches a certain threshold. A scenario in which cycles of different regions may synchronize due to trade linkages among the regions is probable and realistic, but rather straightforward and obvious.

In the present paper, we propose another possible explanation, i.e., an explanation that expectations based on the average level of the economy may induce regional business synchronization, by means of a system of globally coupled, noninvertible maps [9]. A prototype of the globally coupled map (GCM) is represented by

$$x_{t+1}(i) = (1-\varepsilon)f(x_t(i)) + \frac{\varepsilon}{N}\sum_{j=1}^{N} f(x_t(j)), \quad i = 1, 2, \ldots, N, \tag{1}$$

where $x_t(i)$ is the variable of the ith element at discrete time step t, and $f(x)$ represents the endogenous dynamics of each element. For the endogenous dynamics, a noninvertible map which exhibits chaotic behavior is utilized. Since the second term on the right-hand side of (1) represents the global interaction of each element through the mean field, in a system of GCM there are many dynamical elements interacting all-to-all. Two opposite effects coexist: all-to-all coupling is inclined to synchronize elements of the model whereas chaotic instability in each element tends to desynchronize them. Depending upon the balance between these two effects, the GCM model exhibits a rich variety of complex phenomena [9].

2. Model

The economy is divided into N regions, each of which has a separate market. For simplicity, let us suppose that there is only one producer in each region, so that there exist N producers in total in the economy. The producer in each region produces homogeneous goods and supplies them to the market he operates in. Consumers purchase goods from the market they belong to. Since the main focus of the present paper is to show how regional business cycles synchronize through expectations, we perform a kind of thought experiment, in order to segregate expectation effects from trade-linkage effects, and assume that there is no interregional trade. Instead the regional markets are connected with each other in the following way: The government announces the average price and the average output of the whole economy at each time period and the producer decides his production plan for the next period based on such average information and other factors. In what follows, a system of GCM is derived based on a cobweb-type model[2] with adaptive adjustment [10].

At period t, ith producer expects that actual prices $p_t(i)$ in his market will be adjusted adaptively at period $t+1$ toward the average level $\bar{p}_t = (1/N)\sum_{j=1}^{N} p_t(j)$ announced by the government, so that

$$p^e_{t+1}(i) = (1-\varepsilon)p_t(i) + \frac{\varepsilon}{N}\sum_{j=1}^{N} p_t(j), \tag{2}$$

where the superscript e denotes expectation and $\varepsilon \in (0, 1)$ is an expectation adjustment coefficient common to all producers.[3]

Under this price expectation, the expected profit of producer at period $t+1$ is given by $p^e_{t+1}(i)x_{t+1}(t) - C(x_{t+1}(i))$, where $C(x) = x^2/2$ is a cost function. Thus the output which maximizes the expected profit is given by

$$\tilde{x}_{t+1}(i) = p^e_{t+1}(i). \tag{3}$$

In order to hedge against the risk of failure in expectations, producer produces the amount which is a weighted average of the present period's output $x_t(i)$, the average output of the whole economy announced by the government $\bar{x}_t = (1/N)\sum_{j=1}^{N} x_t(j)$, and the output which maximizes the expected-profit $\tilde{x}_{t+1}(i)$. The basic idea

[2]The cobweb model is an economic model which explains why prices and outputs in certain markets are subject to periodic fluctuation. It shows an adjustment process that, on a supply–demand diagram, spirals toward an equilibrium like in a cobweb.

[3]As will be described below, actual prices $p_t(i)$ are determined in the market so as to equilibrate supply and demand.