



Review

Assessing geographical effects in spatial diffusion processes: The case of euro coins



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ABSTRACT

We examine how geographical structures impact diffusion processes within a regional system. From the example of euro coin diffusion across countries, we show how the relative position and population endowment of regions impact our understanding of interregional mobility, beyond simple spatial interaction effects. The mix of coins of different origins is a complex but unique trace of the movement of individuals within a common currency area, potentially revealing a new facet of European integration. We simulate an individual-based dynamic model where agents move and exchange coins across regions. We analyse the convergence towards a homogeneous mix of coins through time for a series of different theoretical spatial systems. This sensitivity analysis demonstrates the impact of the regularity and aggregation levels, or centrality/periphery effects, on spatial diffusion dynamics. We then calibrate the model against empirical data for the regions of 5 European countries and provide estimates of mobility rates, distance decay and population attractiveness factors, affecting the diffusion of coins, hence international movements and European integration.

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1. Introduction

As emphasized by Gould (1969), the study of spatial diffusion processes should neither be reduced to the temporal dimension nor to a static analysis of their spatial patterns. It is well known that spatial processes to which a 'time arrow' is added can follow complex trajectories (Prigogine & Stengers, 1979) and encounter spatial path-dependencies (Whittle, 1954). Diffusion processes in particular are impacted by the geographic complexity of a broad variety of attractors and repellers of human movements (Gould, 1969). In economics it is also well known that cumulative processes can be spatially selective and show dependencies on initial regional conditions (Arthur, 1994; Barro & Sala-i Martin, 1992; Krugman, 1996; Petrakos, Kallioras, & Anagnostou, 2011).

Spatial interactions occur at varying geographical scales and the representation of space need to be adapted to the process under study (Rodriguez-Pose, 2011). However, the analytical tractability of geographical models has often led researchers to a simple treatment of geography, even if acknowledging that spatial simplifications cannot account for the complexity of reality (Fujita, Krugman, & Venables, 2001). New Economic Geography (NEG) models, for example, have been based on two or three regions only, or used an n -regions setting but with a simplistic geometrical structure, e.g. regions equally distributed along a line or a circle, or other symmetrical and equidistant structures (Bosker, Brakman, Garretsen, & Schramm, 2010). While these models can illustrate tendencies they encounter limits to reflect real world amplitudes (Puga & Venables, 1997). If one further recognises the dynamic and cumulative nature of processes, as in diffusion phenomena, spatial simplifications seem to impact results even more. Actually, the effect of using regular structures (lattices) or varying initial configurations is a well recognised problem in agent-based literature since Schelling (1971) and can lead to inappropriate conclusions if the geography is more asymmetric or heterogeneous (Brulhart & Torstensson, 1996; Stanilov, 2012).

In this paper we contribute an analysis of the effects of population size and relative location of places on the rapidity of the diffusion of euro coins using theoretical and empirical geographies and a dynamic disaggregated model. On January 1st 2002, European integration was pushed forward by establishing a common currency for twelve European member states. Each euro coin has on one side a common value symbol and, on the other side, a symbol representing the country where it was minted and started to circulate. Each coin can of course be used everywhere in the eurozone, whatever its production place. This specific feature of euro coins represents a fantastic opportunity to analyse mobility patterns across Europe, which are not revealed in other statistics. While coin diffusion is not a significant part of financial exchanges, observing a 'foreign' coin in a given place is an indirect signal of cross-border mobility for work, leisure, or any other business. It is well known that the mobility of people is subject to spatial interaction laws, in particular distance and agglomeration effects (Ravenstein, 1885; Roy & Thill, 2004; Stouffer, 1940). Conversely to other goods however, cash interactions with euro coins are not subject to additional transaction costs when transferred across states: the value of a coin is constant and there is no taxation at borders. It is therefore a promising tool for revealing 'pure' geographical effects on mobility.

Our analysis aims at answering the following questions: What is the effect of an increasingly complex geographical structure on the stability of the diffusion process? Is the diffusion speed between regions an independent and non-trivial geographical process, as suggested by Hagerstrand (1952)?

The remainder of the paper is organised as follows: in Section (2) we first discuss how money diffusion modelling can add to the European integration literature by emphasizing international mobility of individuals and second review existing cash diffusion models. In Section (3) we present our model and its assumptions regarding agents' mobility and the cash transaction process. In Section (4) we analyse the effects of theoretical spaces and the geography of North-West Europe on diffusion patterns and the convergence time to a steady state. In Section (5) we fit our model to empirical data and estimate convergence time in the eurozone before concluding.

2. Related work and theory

2.1. European integration and the diffusion of euro coins

European integration through the mobility of people, capital, information and ideas was one of the main purposes for the creation of the European Union. In a context of economic crisis and increased regionalism, it is important to assess the strength of territorial integration and European construction. Coin exchange practices can help the assessment of this integration by revealing cross-border mobilities not otherwise systematically reported.

Indeed the question remains of how strongly integrated is the eurozone system across regions and whether it contributes to cancelling out regional disparities within countries as well (Martin, 2001; Petrakos et al., 2011; Puga, 2002). Both Martin (2001) and Puga (2002) stress the need for further consideration of spatial proximity effects or the internal geographical structures of the eurozone in order to better understand polarisation and convergence effects, and eventually fine tune regional policy. However, more data is needed to better understand human capital, technology and knowledge diffusion across regions (Fingleton, 2004, p.397) depending on their characteristics as well as economic integration and long-run convergence (Martin, 2001). Our argument in this paper is that euro coins are an unconventional dataset but a useful marker of daily mobility, of business exchanges and eventually of territorial integration.

We are aware that using euro coins as a marker of mobility may suffer from biases. In particular, there might be differences in payment practices (use of cash, cards,...) across eurozone countries. Second, there have been differences in the way the spatio-temporal distribution of coins has been recorded in each country (Grasland, Guérin-Pace, Le Texier, & Garnier, 2012). Third, coin exchange is only an indirect and small part of economic integration, compared to investments' flows or all kinds of bank transfers between firms and households of different countries. Despite these limits, using the diffusion of euro coins to analyse integration has a series of advantages. First, the diffusion of euro coins may well reflect a deeper view of economic integration that touches individuals directly, even if cash payments are only a small part of their budget. With the understanding that economic action 'is embedded in structures of ongoing social relations' (Bathelt & Glückler, 2003; Granovetter, 1985), adopting this coin perspective actually complements the literature that is mainly limited to economic aggregates. The spatial distribution and diffusion of euro coins across Europe reflect the mobility of people within and across states via the cumulative effects of many small cash transactions.

Second, the diffusion of coins by individuals represents an important share of exchanges. For instance, in Germany, the volume of coins carried in households' wallets (estimated to 410 million euros in 2011) exceeds largely the volume of coins held by credit institution (between

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