Interdependence in Comparative Politics: Substance, Theory, Empirics, Substance

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Abstract: Interdependence is ubiquitous, and often central, across comparative politics. In comparative political economy, for example, globalization and rising capital mobility imply tax competition that suggests the fiscal policies of one country must depend crucially upon those of other countries with which it competes for capital. This paper shows this theoretically and, more generally, how any situation involving externalities from one unit’s actions on others’ implies interdependence. Positive/negative externalities induce negative/positive interdependence, which spurs competitive-races/free-riding, with corresponding early/late-mover advantages, and so strategic rush-to-act/delay-and-inaction. We show next how to model such interdependent processes empirically, that not doing so risks severe omitted-variable biases that erroneously favor domestic and exogenous-external accounts over interdependence but that doing so naively risks simultaneity biases with the opposite substantive implications. Then we discuss how to estimate properly specified interdependence models with spatial lags by maximum likelihood and, finally, how to interpret and present the resulting estimated spatio-temporally dynamic effects, response paths, and long-run steady-states, with their associated standard errors. We illustrate all this by replicating a noteworthy earlier, non-spatial, study of capital-tax competition. Web appendices contain further technical details, literature survey, data, statistical-software code, and spreadsheet templates for conducting all estimation and calculation procedures.
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I. The Broad Substantive Range of Spatial Interdependence

Until recently, empirical analyses of spatial interdependence (or *diffusion*) in the social sciences remained largely confined to specialized areas of applied economics (e.g., urban/regional, real-estate, environmental) and sociology (i.e., network analysis). However, social-scientific interest in and applications of spatial modeling have burgeoned lately, due partly to advances in theory that imply interdependence and in methodology to address it; partly to global substantive developments that have raised perception of and attention to interconnectivity, at all levels, from micro/personal to macro/international; and partly to advances in technology for obtaining and working with spatial data. In comparative politics too, spatial analyses are increasingly common, a welcome development as many of the phenomena comparativists study entail substantively crucial spatial interdependence.


The substantive range of important spatial-interdependence effects extends well beyond inter-
governmental diffusion, however, spanning the substance of comparative politics. Inside democratic legislatures, representatives’ votes depend on others’ (expected) votes (Lacombe & Shaughnessy 2005), and, in electoral studies, citizens’ votes, election outcomes, or candidate qualities, strategies, or contributions in some contests depend on those in others. Outside legislative and electoral arenas, the ignition and/or outcomes of coups (Li & Thompson 1975), riots (Govea & West 1981), civil wars or revolutions (Brinks & Coppedge 2006) in one unit depend on those in others. In microbehavioral work, too, much of the surging interest in contextual/neighborhood effects surrounds effects on respondents’ behaviors or opinions of aggregates of others (e.g., those of the respondent’s community or social network). Interdependence in social-movements, national identity (Lin et al. 2006), and right-wing extremism (Rydgren 2005) has also gained attention. In comparative political economy, too, interdependence is often substantively large and central. Simmons & Elkins (2004), e.g., stress cross-national diffusion as the main force behind recent economic liberalizations, as do many others. Even more broadly, globalization, i.e., international economic integration, arguably today’s most-notable (and indisputably its most-noted) political-economic phenomenon, implies strategic (or nonstrategic) interdependence of domestic politics, policymakers, and policies. Studies exploring such globalization-induced interdependencies are beyond rife.

In this paper, we first introduce the theory and substance of interdependence, (1) emphasizing the multifarious mechanisms by which it arises across the political and social sciences, (2) offering a generic theoretical model establishing the rich and interesting logical connections from externalities to interdependence, and (3) introducing globalization and tax-competition as an important, specific substantive context in which interdependence figures prominently. We next (1) address the severe empirical challenges in effectively and correctly distinguishing interdependence from other potential sources of spatial correlation, (2) show how to specify and estimate empirical models that can make such distinctions, and (3) show how to interpret and present effectively the results of such models. Lastly, we illustrate all this specifically in the context of globalization, international tax-competition,
and domestic policymaking autonomy, thus completing the paper’s subtitular cycle in proceeding from the substance, to the theory, to the empirical specification and estimation, and back to the substantive interpretation and presentation of spatial interdependence in comparative politics.

**II. The Myriad Mechanisms, a General Theoretical Model, and an Example Substantive Context**

Throughout comparative politics, spatial interdependence is ubiquitous and often quite central. As *Tobler’s First Law of Geography* (Waldo Tobler: 1930-) aptly sums: “Everything is related to everything else, but near things are more related than distant things.” What’s more, as Beck et al.’s (2006) pithy title stresses: “Space is More than Geography.” That is, the substantive content of the proximity in Tobler’s Law, and so the pathways along which interdependence among units may operate, extend well beyond simple physical distance and bordering (as several of the examples above illustrate). Elkins & Simmons (2005) and Simmons et al. (2006), for example, define and discuss four mechanisms by which international diffusion may arise. *Coercion*, which may be direct or indirect and hard (force) or soft (suasion), encompasses a generally vertical pathway by which the powerful induce actions among the weaker. *Competition* refers to interdependence stemming from economic pressures that the actions of each unit place upon others as competition with, substitutes for, or complements to it. *Learning* entails situations where actors learn, in rational-Bayesian or some other fashion, something from others’ actions about qualities of their own alternative actions.\(^{14}\) *Emulation*, finally, is ritualistic (i.e., not coerced or responsive to competition or learning) following or doing oppositely of others (e.g., leaders, co-ethnics, co-partisans). To these, we would add a fifth channel, *migration*, wherein some components of some units directly enter other units, the most obvious examples being disease contagion or human im-/emigration, which will tend to generate a direct, mechanical interdependence in addition to strategic or idea-dissemination.

More generally, following Brueckner (2003), we can show that strategic interdependence arises whenever some unit(s)’s actions affect the marginal utility of alternative actions for some other(s). Consider two units \((i, j)\) who derive indirect utilities, \((W_i, W_j)\), from their alternative actions. Due to
externalities, i’s utility depends on its policy and that of j. For example, imagine two countries with homogenous populations regarding their, say, economic and environmental preferences. Due to environmental externalities (those surrounding pollution) and economic ones (those surrounding the costs of environmental regulations), domestic welfare (or the net political-economic benefits/utilities to policymakers) in each country will depend on both countries’ policies, \((p_i, p_j)\):

\[
W^i \equiv W^i(p_i, p_j) \quad ; \quad W^j \equiv W^j(p_j, p_i)
\]

When country \(i\) chooses its policy, \(p_i\), to maximize its own welfare, this alters the optimal policy in country \(j\), and \textit{vice versa}. For example, as \(i\) implements more-effective anti-pollution policy, the need for effective anti-pollution policy in \(j\) declines due to environmental spillovers. We can express such strategic interdependence between countries \(i\) and \(j\) with a pair of best-response functions, giving \(i\)’s optimal policies, \(p_i^*\), as a function of \(j\)’s chosen policies, \(p_j\), and \textit{vice versa}:\(^{15}\)

\[
p_i^* \equiv \text{Argmax}_{p_i} W^i(p_i, p_j) \equiv R^i(p_j) \quad ; \quad p_j^* \equiv \text{Argmax}_{p_j} W^j(p_j, p_i) \equiv R^j(p_i)
\]

The slopes of these best-response functions, \(R^i(p_j)\) and \(R^j(p_i)\), indicate whether actions by \(i\) induce \(j\) to move in the same direction, in which case we call the actions of \(i\) and \(j\) \textit{strategic complements}, or in the opposite direction, in which case they are \textit{strategic substitutes}. For example, anti-pollution policies are strategic substitutes in terms of their environmental effects as described above. These best-response functions’ slopes depend on the following ratios of second cross-partial derivatives:

\[
\frac{\partial p_i^*}{\partial p_j} = -W^i_{p_i,p_j} / W^i_{p_i,p_i} \quad ; \quad \frac{\partial p_j^*}{\partial p_i} = -W^j_{p_j,p_i} / W^j_{p_j,p_j}
\]

If governments maximize, the second-order conditions assure that (3)’s denominators are negative, so the reaction-function slopes depend directly on the signs of the second cross-partial derivatives in the numerators. If \(W^i_{p_i,p_j} > 0\), that is, if policies are strategic complements, reaction functions slope upward. In the economic costs of anti-pollution regulation, for example, tighter regulation in \(i\) lowers the costs of regulation in competitors \(j\), and so spurs \(j\) to tighten regulation too. (See Figure 1 as an
example.) If $W^{i,j}_{p,p'} < 0$, policies are strategic substitutes, so reaction functions slope downward, as noted with regard to the environmental benefits of anti-pollution regulation above. If $W^{i,j}_{p,p'} = 0$, strategic interdependence does not materialize, and best-response functions are flat.

[Figure 1 Here]

Generally speaking, then, positive externalities induce strategic-substitute relations, and policies will move in opposite directions as free-rider dynamics obtain. Franzese & Hays (2006b) argue and find such free-riding dynamics in EU active-labor-market policies, for instance. Notice, furthermore, that free-rider advantages also confer late-mover advantages, and so war-of-attrition (strategic delay or inaction) dynamics are likely. Conversely, negative externalities create strategic complementarity, with policies moving in the same direction. Tax competition has these features. Tax cuts in one unit have negative externalities for competitors, pushing them to cut taxes in response. These situations advantage early movers, so competitive races can unfold.16 Earlier movers also reap disproportionate benefits in the contexts of competitive currency-devaluations or trade-barriers. Thus, positive and negative externalities induce strategic-complement and substitute relations, respectively, which spur competitive-races and free-riding, respectively, with their corresponding early- and late-mover advantages, and so strategic rush to go first on the one hand and delays and inaction on the other.

In this frame, globalization, specifically capital mobility, which example we elaborate next and (re-)analyze empirically below, creates strategic policy-interdependence because it heightens cross-border negative externalities in capital-tax policy. If this rising sensitivity steepens positively sloped reaction-functions, competitive tax-cut races ensue. In theory, by extension, such inter-jurisdictional competition for capital, which intensifies as capital grows more-liquid and -mobile across borders, undermines the tax-policy autonomy of individual states, pushing tax rates to converge downward, especially those levied on more-mobile assets. Indeed, many scholars of domestic or international fiscal-competition (e.g., Zodrow & Mieszkowski 1986; Wilson 1986, 1999; Wildasin 1989; Oates
2001) expect intense such competition to unleash nearly unmitigated races to some (*ill-defined*; see note 16 and below) bottom. Scholarly and casual observers alike see the striking post-1970s rise in international capital-mobility and steady postwar increase in trade integration as forcing welfare- and tax-state retrenchment and shifting tax-burden incidence from relatively mobile bases (capital, especially finance) toward more immobile (labor, especially less-flexibly-specialized labor).\textsuperscript{17} Rising portfolio- and fixed-capital-market integration, in this view, sharpen capital’s threat against domestic governments to flee perceived excessive and inefficient welfare and tax systems.

Several recent studies of tax policy over this period challenge these claims. Quinn (1997), Swank (1998, 2002), Swank & Steinmo (2002), Garrett & Mitchell (2001), and others find international economic integration not to have constrained governments’ fiscal policies much. Explanations for this begin by noting that other national differences also heavily affect investment-location decisions, affording governments maneuvering room. Hines (1999), for instance, finds firms consider final-market proximity, intermediate-supply availability, commercial, regulatory, and other policies, and labor-market institutions, among many other factors. Likewise, governments’ tax policies respond to more than just competition for capital. For example, Swank (2002) finds corporate and capital tax-rates depend on macroeconomic growth and inflation, funding requirements of programmatic outlays, and partisan politics. Controlling for these domestic factors, he finds little relation of taxation to capital mobility, although including spatial lags to reflect tax-policy interdependence as in our re-analyses below and his own subsequent work (e.g., 2006) alters that conclusion. Even so, many studies find domestic political-economic factors affect fiscal policy at least as strongly as do external or globalization-related factors. Our empirical re-analysis returns to this question.

On closer analysis, these recent challenges to simplistic *globalization-induces-welfare/tax-state-retrenchment* views have at least four distinct bases. Garrett (1998) argues that certain combinations of left-government associated policies and labor-market coordination can be as or more efficient than neoliberal state-minimalism and conservative government. Capital, he argues, would not flee such
efficient combinations. Boix (1998) argues that public human- and physical-capital investment-strategies comprise an alternative to neoliberal minimalism that is sufficiently efficient economically to retain capital and politically effective enough to sustain left electoral-competitiveness. Soskice, Hall, and colleagues (2001) argue that complex national networks of political-economic institutions confer sectoral comparative advantages. As Franzese & Mosher (2002) elaborate, this implies capital mobility and trade integration would (if international tax-competition remains sufficiently muted: see below) favor institutional specialization: persistent welfare/tax-system variation or even divergence, not convergence or global retrenchment. These three views, plus a fourth stressing globalization-stoked perceptions of economic insecurity that spur welfare-state demand (Rodrik 1997, Scheve & Slaughter 2004), fundamentally question whether globalization creates net pressures to retreat from welfare/tax-state commitments (or at least whether all aspects of globalization do so, so strongly).

In a fifth line of counterargument, Swank (2002) contends that the institutional structures of the polity and the welfare system itself shape the domestic policy-response to integration. He neither fundamentally challenges the claimed exclusively superior macroeconomic efficiency of neoliberal minimalism nor stresses the demand-spurring effects of globalization-stoked economic insecurities. Rather, he pushes the primacy of domestic political conditions—the policymaking access, cohesion and organization, and relative power of contending pro- and anti-welfare/tax interests—in shaping the direction and magnitude of welfare/tax-policy reactions to economic integration. Specifically, he finds inclusive electoral institutions, social-corporatist interest-representation and policymaking, centralized political-authority, and universal welfare-systems favor pro-welfare interests in the domestic political struggle over policy responses to integration. Capital mobility and globalization, meanwhile, further welfare/tax-state largesse in previously generous states and retrenchment in tight ones. That is, Swank suggests divergence for domestic reasons not convergence for external or interdependent ones.¹⁸ Basinger & Hallerberg (2004) take the next step. If “countries with higher political costs are less likely to enact reforms, [and this] reduces competing countries’ incentives to
reform regardless of their own political costs” (2004:261). The magnitude of the tax-competition pressures that economic integration places upon one government’s fiscal policies depends upon its competitors’ policy choices, which is exactly the strategic interdependence we emphasize here.

Such critiques also highlight that the bottom toward which globalization and capital mobility may push tax-competing states need not be neoliberal minimalism. Insofar as alternative political-economic advantages or constraints allow or force some states to retain high taxes, the competitive pressures on all states diminish. The more integrated and important are the domestically advantaged or constrained states, the more the pressures diminish. Furthermore, if, as Franzese & Mosher (2002) suggest, national economic-policy differences help shape comparative advantages, then both trade and global fixed-capital integration would enhance economic pressures for specialization: divergence, not convergence. From this view, international liquid-capital mobility alone, through the tax-competition it engenders, induces whatever competitive races may occur.19 Finally, as Hays (2003) and Basinger & Hallerberg (2004) stress, such races need not be to some bottom at all; rather, the race’s competitiveness and its destination depend on the constellation of domestic political-economic conditions present in, and the economic integration of, the international system.

Thus, international tax- and fiscal-policy competition arguments, in any of their conventional forms and throughout each of these critiques, imply cross-national (i.e., spatial) interdependence in fiscal policymaking. Whatever pressures on domestic policymaking may derive from rising capital mobility, their nature and magnitude will depend on the constellation of tax (and broader economic) systems with which the domestic unit competes. As we have shown, race-to-the-bottom dynamics may occur when policies are strategic complements, that is, when policy changes in one unit create incentives for others to adopt similar changes. For example, cuts in capital taxes or costly labor, environmental, or other regulatory standards in one unit increase the costs to others of maintaining high taxes and regulatory standards, inducing them follow suit. By contrast, free-riding occurs when policies are strategic substitutes, that is, when policy changes in one unit create incentives for others
to adopt change in the opposite direction. For example, an increase in defense expenditures in one country lowers the marginal security benefit from defense spending in its military allies, creating an incentive for them to free ride (e.g., Redoano 2003). We gave a general theoretical formulation of interdependence in these terms above, following Brueckner (2003); a web appendix follows Persson & Tabellini (2000:ch.12) to elaborate formally how tax competition specifically implies spatial interdependence. The model shows how domestic policymakers’ optimal capital-tax-rates, $\tau_k$, depend not only on their own tax-policy orientation, captured in the model by their labor-endowment, $e^P$, but also on foreign capital-tax-rates, $\tau_k^*$, (and so on foreign endowments, $e^{P^*}$). That is, the model yields best-response functions in the specific forms $T(e^P, \tau_k^*)$ and $T^*(e^{P^*}, \tau_k)$ for domestic and foreign policymakers, respectively. Figure 1 graphs those assuming positive slopes. The comparative-static shows an increase in the domestic policymaker’s labor-endowment (a leftward shift), which shifts the domestic function outward and so raises equilibrium capital-tax rates in both countries.

Although formal tax-competition models like this one, or Hays (2003), or Basinger & Hallerberg (2004), unambiguously demonstrate the strategic spatial-interdependence of capital taxes, as do the alternative arguments reviewed above, not all tax/welfare-state retrenchment arguments necessarily involve tax-competition. In Iversen & Cusack (2000), for example, structural labor-force changes, specifically deindustrialization, are the main force pushing welfare/tax-state retrenchment. Pierson’s (1994) account emphasizes path dependence, i.e., the accumulation and entrenchment of interests (or their absence) behind welfare-state policies and institutions (technically: state, not path, dependence: Page 2006). Cameron (1978), Rodrik (1997), and Scheve & Slaughter (2004) stress instead demand for social policies arising from domestic interests experiencing increased economic exposure.

Such forces—labor-force structural-change, domestic-interest entrenchment and/or change—may be related to, or even partly caused by, aspects of globalization, but, ultimately, these are domestic-factor explanations or arguments about exogenous external trends. Therefore, by themselves they do not imply any of the strategic interdependence among policy choices that tax-competition theories,
instead, emphasize. We term approaches that combine these to reflect domestic factors, exogenous-external factors, and context-conditional responses to exogenous-external conditions on one hand and international interdependence on the other Comparative-and-International Political-Economy (C&IPE). We will (re-)analyze two such C&IPE empirical models in the globalization and capital-tax-competition context below. First, though, we must explain the severe empirical difficulties in accurately estimating and distinguishing these alternative components of C&IPE models, and then discuss some methodological approaches that may surmount these difficulties.

**III. Empirical-Methodological Challenges of Spatial Interdependence**

We begin by distinguishing four broad approaches in comparative politics to explaining cross-unit variation and offering a generic empirical model that represents each. One approach prioritizes unit-level (individual, domestic) factors, ignoring contextual effects and interdependence processes. A second grants key roles to external/contextual shocks/conditions. In a third, a unit’s responses to exogenous-external conditions may depend on that unit’s characteristics, and, *vice versa*, the effects of unit-level characteristics may depend on context, but with context remaining exogenously external to units. In these last two forms, exogenous-external conditions affect units’ outcomes (commonly or context-conditionally), but units’ outcomes do not directly affect other units’ outcomes. Thus, no reverberation occurs. In truly interdependent processes, contrarily, outcomes in some units directly affect other units’ outcomes, implying feedback. A country may respond to an exogenous domestic or external shock by cutting capital-taxes (unit- or contextual-level), and its response to external shocks may depend on domestic factors (context-conditional), but its response may further depend on what competitors do and, conversely, its own response may affect other policymakers’ choices (interdependence). Analogously, German and French respondents’ opinions might correlate because individual characteristics (unit-level) correlate spatially, or because political-economic conditions correlate regionally (exogenous-external context). Respondents’ opinions may react to common regional stimuli differently depending on their individual characteristics (context-conditional). Yet
opinions may also correlate regionally because each respondent’s opinion depends on others’ opinions, for instance: those of “neighbors” or other regional residents (interdependence). Notice this important implication of the concluding phrases of each example: in interdependent processes, outcomes (i.e., dependent or left-hand-side variables, \( y_i \), or components thereof, \( \hat{y}_i \) or \( \varepsilon_i \)) in some units are among the explanators (right-hand-side or “independent” variables) of outcomes in others.

A central challenge for empirical researchers, known as *Galton’s Problem*, is the great difficulty distinguishing common shocks (correlated responses to correlated unit-level, contextual, or context-conditional factors) and interdependence. As elaborated later, on one hand, ignoring or inadequately modeling interdependence processes leads analysts to exaggerate the importance of common shocks, privileging contextual/exogenous-external or unit-level/domestic-factor accounts. On the other hand, if the inherent simultaneity of interdependence is insufficiently redressed, then analysts will misestimate (usually overestimate) the strength of interdependence at the expense of unit-level, external, or context-conditional factors, especially insofar as these common shocks are inadequately modeled.

We begin with a strictly unit-level model of a single outcome. In closed-polity/economy CP/CPE approaches, for instance, domestic political-economic institutions (e.g., electoral systems or central-bank autonomy), structures (e.g., cleavages or economic-industrial structures), and conditions (e.g., electoral competitiveness or business cycles) are the paramount explanators of domestic outcomes. Such domestic-primacy substantive stances imply theoretical and empirical models of this form:

\[
y_{it} = \beta' d_{it} + \varepsilon_{it}
\]  

(4),

where \( y_{it} \) are the outcomes to be explained and \( d_{it} \) are the domestic or unit-level/individual factors that explain \( y_{it} \). Most early empirical studies in CP/CPE, whether quantitative or qualitative, took this form.\(^{21}\) CPE examples include most early work on fiscal and monetary policy (Tufte 1978, Hibbs 1987, and successors), corporatist wage-bargaining (Cameron 1984, Lange & Garrett 1985, successors), or central-bank independence (Cukierman 1992, Alesina & Summers 1993, successors).
As economies grew more interconnected by international trade and, later, finance, and as perhaps polities’ geopolitical interconnectedness rose also, controls for effects of global political-economic conditions on domestic policies and outcomes became both more important substantively and more common in practice. At first, however, global conditions were assumed to affect all units equally and so to induce equal responses from each unit, yielding theoretical/empirical models like this:

$$y_{it} = \beta'_d d_{it} + \beta'_s s_{it} + \varepsilon_{it}$$

(5),

where $s_{it}$ are global shocks (e.g., the oil crises), felt equally by all the sample spatial units, each of which respond equally (each $i$ feels identical shocks, $s_{it}$, and responds thereto by the same amounts, $\beta_s$). Examples of empirical models reflecting such stances include many post-oil-crisis political-economy studies, including later rounds of the above literatures, wherein time-period dummies or controls for global economic conditions or differencing of domestic from global conditions began to appear. See, for example, Alvarez et al. (1991) on partisanship and corporatism; Alesina et al. (1997) on political and/or partisan cycles; Powell & Whitten (1993) on economic voting.

Modern institutional or other context-conditional arguments stress varying unit responses to external/contextual stimuli depending on unit-level characteristics. Domestic institutions, structures, and conditions shape the degree and nature of domestic exposure to external shocks or of domestic policy-outcome responses to these differently felt foreign stimuli, for example; and individuals’ education or attention levels moderate their opinion/behavioral responses to contextual factors like the party systems in which they vote. This yields characteristic theoretical and empirical models:

$$y_{it} = \beta'_d d_{it} + \beta'_s s_{it} + \beta'_{ds} (d_{it} \otimes s_{it}) + \varepsilon_{it}$$

(6),

where the incidence, impact, or effect of contextual/external common shocks, $s_{it}$, on domestic/unit-level outcomes, $y_{it}$, are conditioned by domestic/unit-level contextual factors, $d_{it}$, and so differ across units. Much of modern CP/CPE is of this form, including the Iversen-Cusack or Cameron-Rodrik welfare-state retrenchment arguments mentioned earlier, Garrett (1998), and Franzese (2002).
Analyses that recognize the *interdependence* of outcomes across units, contrarily, must have unit $i$ and unit $j$ outcomes affecting each other, yielding this final extension of the generic model:

$$y_{it} = \rho \sum_{j \neq i} w_{ij} y_{jt} + \beta_d' d_{it} + \beta_s' s_{it} + \beta_{sd}' (d_{it} \otimes s_{it}) + \epsilon_{it} \tag{7},$$

where $y_{jt}$ are the outcomes in the other ($j \neq i$) units, which in some manner (given by $\rho w_{ij}$) directly affect the outcome in unit $i$. Note that $w_{ij}$ reflects the *relative degree* of connection from $j$ to $i$, and $\rho$ reflects the overall *strength of interdependence* of the outcome in $i$ on the outcomes in the other ($j \neq i$) spatial units, as weighted by $w_{ij}$. Substantively, in the tax-competition venue, for example, the $w_{ij}$ could gauge the sizes or the similarity (substitute) or complementarity of $i$’s and $j$’s economies or of their capital or goods-and-services trade. The other right-hand-side factors reflect the model’s non-spatial components: unit-level/domestic, contextual/exogenous-external, and context-conditional.\(^{27}\)

Since models like (12) subsume those like (9)-(11), one might argue to begin always with (12) or (9) and work downward or upward as data suggest/allow. However, as we summarize below (from Franzese & Hays 2004, 2006a, 2007c, 2008ab), obtaining ‘good’ (unbiased, consistent, efficient) estimates of coefficients and standard errors in such models and, more generally, distinguishing interdependence processes from correlated unit-level, exogenous-external, or context-conditional factors by any empirical method, is *not* straightforward. The first and prime consideration in doing so is the relative and absolute theoretical and empirical precisions of the spatial (interdependence) and non-spatial (common/correlated domestic/unit-level, exogenous-external, or context-conditional) parts of the model or theory. To elaborate, the relative and absolute accuracy and power with which the spatial-lag weights, $w_{ij}$, measure and offer leverage on the *interdependence* mechanisms actually operating, and with which domestic, exogenous-external, and/or context-conditional components measure and offer leverage upon the *common-shocks* alternatives, critically affect any attempt to distinguish and evaluate their relative strength empirically. This is *Galton’s Problem*:\(^ {28} \) intuitively, the two mechanisms produce similar effects, so inadequacies or omissions in specifying the one tend
to induce overestimates of the other’s importance. Secondarily, though, even with the common-
shocks and interdependence mechanisms both modeled perfectly, the spatial lags will be endogenous
(i.e., covary with residuals), so estimates of $\rho$ will suffer simultaneity biases (as, equally, would any
qualitative attempt to distinguish interdependence from domestic or exogenous-external accounts).
Moreover, conversely to the primary omitted-variable or relative misspecification biases explained
first, these simultaneity biases tend toward over-estimating interdependence strength and inducing
biases in the opposite direction, under-estimating the domestic and/or exogenous-external.

Most of the empirical research on globalization/tax-competition and fiscal-policy autonomy or
policy diffusion analyzes panel or time-series-cross-sectional (TSCS) data (i.e., observations on units
over time). Sound empirical inference will therefore require careful modeling of temporal and spatial
interdependence.29 We have seen above that, theoretically and substantively, failure to model spatial
interdependence is a serious misspecification risking sizable omitted-variable bias, particularly in
fiscal-policymaking contexts. The easiest and most direct way to incorporate this interdependence is
with a spatio-temporal lag model, which we can write in matrix notation as:

$$y = \rho Wy + \varphi My + X\beta + \epsilon$$  

Where $y$, the dependent variable, is an $NT \times 1$ vector of cross sections stacked by period (i.e., all $N$
units’ first-period observations, then their second periods, and so on to the $N$ for period-$T$.30 $\rho$ is the
previously described spatial autoregressive coefficient, and $W$ is an $NT \times NT$ block-diagonal spatial-
weighting matrix. $Wy$ is the spatial lag; i.e., for each observation, $y_{it}$, $Wy$ is a weighted sum of the
other units’ outcomes, $y_{jt}$, with weights $w_{ij}$ reflecting relative connectivity from $j$ to $i$.31 $Wy$ thus
straightforwardly reflects the dependence of each unit $i$’s outcome on unit $j$’s, directly following the
theoretical models and substantive arguments reviewed above. $M$ is an $NT \times NT$ matrix with ones on
the minor diagonal (i.e., at $(N+1, 1)$, $(N+2, 2)$, $(NT, NT-N)$), and zeros elsewhere, so $My$ is just the
familiar (first-order) time-lagged dependent-variable, with $\varphi$ its coefficient. The matrix $X$ contains
$NT$ observations on $k$ independent variables, with $\beta$ their $k \times 1$ vector of coefficients. In our generic
models, $\mathbf{X}$ has columns $\mathbf{d}$, $\mathbf{s}$, and $\mathbf{d} \otimes \mathbf{s}$. Thus, $\mathbf{X} \boldsymbol{\beta}$ is the non-spatial, or *common-shocks*, components of domestic/unit-level, contextual/exogenous-external, and context-conditional factors. Finally, $\varepsilon$ is an $NTx1$ vector of stochastic components, assumed independent and identically distributed. The spatio-temporal-lag model thus captures temporal and spatial dynamics in a familiar form. It simply regresses the outcome, $y_{i,t-1}$, on exogenous domestic/unit-level and contextual/external explanators, $\mathbf{x}_{i,t}$, a time-lagged dependent-variable, $y_{i,t-1}$, and a weighted average of the dependent variable in other units, $\sum_j w_{ij} y_{j,t}$, with the weights, $w_{ij}$, reflecting the relative connectivity from units $j$ to unit $i$.

In earlier work (2004, 2006a, 2007c, 2008ab), we explored analytically and by simulation several properties of four estimators for such models: non-spatial least-squares (i.e., regression omitting the spatial component as is common in most extant research: OLS), spatial OLS (i.e., OLS estimation of models like (8), which is becoming common in diffusion studies: S-OLS), instrumental variables (e.g., spatial 2SLS or S-2SLS), and spatial maximum-likelihood (S-ML). Analytically, we can show that the first two strategies yield biased and inconsistent estimates, the first due to omitted-variable bias and the second due to the endogeneity of the spatial lag (simultaneity bias). These biases reflect the terms of Galton’s Problem. On one hand, if researchers omit the spatial lag necessary to reflect the actual interdependence of their data, their OLS coefficient-estimates for domestic, exogenous-external, or context-conditional factors will suffer serious omitted-variable biases. The web appendix gives specific formula for these biases, but the important upshot is this: Insofar as spatial lags covary with the non-spatial regressors, which is highly likely if domestic conditions correlate spatially and is certain for common exogenous-external shocks, OLS overestimates domestic, exogenous-external, or context-conditional effects while ignoring spatial interdependence. Notice that this applies equally to qualitative analyses that ignore interdependence sources of their observed phenomena. However, OLS estimation of models including spatial lags (or qualitative observation of the spatial correlation of outcomes across units or tracing of putative diffusion processes) entails an endogeneity— spatial lag, $\mathbf{W}_y$, covaries with residual, $\varepsilon$— and so simultaneity bias/inconsistency. Simply: spatial lags are
weighted averages of outcomes in other units; they thus place some observations’ left-hand sides on others’ right-hand sides. Simpler still, by example: Germany causes France, but France also causes Germany: textbook simultaneity. The web appendix gives specific formulae for these simultaneity biases. The expressions are more complicated, but their crucial upshot may be summarized thus: In the likely common case of positive interdependence and positive covariance of spatial-lag and exogenous regressors, for instance, one would overestimate the interdependence-strength, $\hat{\rho}$, and correspondingly underestimate temporal dynamics, $\hat{\phi}$, and domestic/external/contextual effects, $\hat{\beta}$.

In sum, Galton’s Problem is that empirical analyses (by any method) that ignore interdependence will thereby tend to overestimate the role of non-spatial factors (with the effects of those factors that correlate most spatially being most overstated) and so privilege domestic/unit-level, exogenous-external, and context-conditional accounts and theories. Conversely, just controlling (or considering qualitatively) spatial-lag processes induces simultaneity biases, typically in the opposite direction, that exaggerate the extent of interdependence and understate domestic/unit-level, exogenous-external, and context-conditional effects. Again, those factors that most correlate spatially with the pattern of interdependence will tend to see the greatest induced deflation bias. These conclusions hold as a matter of degree as well. Insofar as non-spatial components are inadequately specified and measured relative to its interdependence components, the latter will be privileged and the former disadvantaged, and vice versa. Thus, careful, accurate, powerful specification of $W$—the patterns of relative interconnectivity—is of crucial empirical, theoretical, and substantive importance to those interested in interdependence, obviously, but also to those for whom domestic/unit-level, exogenous-external, or context-conditional factors are of primary interest. Conversely, specification of non-spatial components is of equally crucial importance to those interested in gauging interdependence.

Our previous work also showed that the omitted-variable biases of OLS are usually worse and often far worse than S-OLS’ simultaneity biases. Under modest interdependence strength ($\rho \bar{W}_g$
comfortably less than 0.3 or so), in fact, S-OLS may perform adequately (although standard-error inaccuracy can be an issue, and in a manner for which PCSE’s do not properly compensate). Faced with ignoring interdependence or modeling it without redressing the simultaneity, therefore, one should generally strongly prefer the latter. However, S-OLS’ simultaneity biases do grow sizable as interdependence strengthens, rendering the consistent estimators, like S-ML or S-2SLS, increasingly advisable. Our analyses of estimator bias, efficiency, and standard-error accuracy found the choice of which consistent estimator decidedly secondary, but S-ML emerges nearly weakly dominant.35

IV. Estimation of Spatial and Spatio-Temporal Models of Interdependence

We introduce estimation only very briefly and generally here.36 First, some practical notes: we have found existing Stata code for spatial analysis unreliable and/or extremely computer-time intensive. We recommend J.P. LeSage’s MatLab code instead. Our replication data, MatLab code, prototype Stata code for S-ML estimation, and Excel spreadsheets for calculations and presentations that might make useful templates, are available at www.umich.edu/~franzese/Publications.37

Next, as the preceding section concluded, the first-order issue in empirical spatial-analysis is to model interdependence where it is appreciably present, i.e., to include spatial lags. Estimating spatial-lag models by OLS yields biased estimates though; not too badly biased if interdependence remains mild, but, even then, standard-error accuracy is elusive (and PCSE’s no help). A simple alternative that may ease or even erase these problems S-OLS is to time-lag the spatial-lag (Beck et al. 2006; Swank 2006). Insofar as a time-lagged spatial lag is pre-determined—that is, insofar as the interdependence is not instantaneous, where instantaneous means within an observation period, given the model—no bias arises. In other words, if spatial-interdependence processes have no effect within an observational period, and if spatial and temporal dynamics are sufficiently well-modeled to prevent spatial-interdependence from manifesting instantaneously due to measurement/specification error, OLS with a time-lagged spatial-lag regressor is an effective estimation strategy.38 Following estimation of such time-lagged spatio-temporal models with tests of whether temporal and/or spatial
correlation remains in residuals is highly advisable. Standard Lagrange-multiplier tests for remaining
temporal correlation in regression residuals remain valid. Franzese & Hays (2004, 2008b) introduce
several tests/measures of spatial correlation, some of which are applicable to S-OLS residuals.

Unfortunately, within observational-period spatial-interdependence is almost certain in the tax-
competition context. First, the capital flows/threats that apply inter-jurisdictional pressures are all-
but-literally continuous, whereas tax-rate policymaking is far slower (annual). Second, in strategic
contexts more generally, units’ equilibrium actions depend on others’ expected actions, implying
instantaneous interdependence. Thus, even if we expect only weakly interdependent policymaking,
and even if we were willing to tolerate possibly inaccurate standard errors, capital-tax competition
would still not be a good candidate for this simplest strategy. We need one of the other estimators.

The endogeneity in S-OLS estimation is that Wy and ε covary. The instrumental-variables/two-
stage-least-squares/generalized-method-of-moments (IV/2SLS/GMM) family of estimators’ strategy
against such problems is to find instrumental variables that correlate with the endogenous regressor
but not with the residual or, restated intuitively, that affect the offending regressor, here the spatial
lag, Wy, but that do not affect the outcome, yi, except through Wy. Spatial IV/2SLS/GMM exploit
the data’s spatial structure for instruments. Unless what we call cross-spatial endogeneity, some yi
causing some xj, exists, WX, the spatial lags of the non-spatial regressors, X, are ideal instruments.
Cross-spatial endogeneity seems unlikely in many contexts (e.g., German capital-tax policy affecting
French voter-participation?), but combinations of vertical connections from yi to yj (interdependence)
and horizontal ones from yi to xj (standard reverse-causality) combine to give the offending diagonal
ones from yi to xj. Insofar as such cross-spatial endogeneity does not exist, though, our analyses
show S-2SLS yields unbiased coefficient-estimates and solid standard-error accuracy. Implementing
2SLS requires no additional code in most statistical software, so, despite its inefficiency relative to
S-ML, manually creating instruments WX to apply S-2SLS may reasonably become popular among
practitioners. However, instrumental-variable strategies like S-2SLS can become “cures worse than
the disease” if their assumptions are violated. Fear of cross-spatial endogeneity in S-2SLS and the slightly stronger performance of S-ML generally should therefore recommend the latter.

S-ML estimation addresses the simultaneity issues of spatial-lag models by solving the system of equations (one per unit) to move all the endogenous variables, $y$ and $Wy$, to the left-hand side, and then maximizing the likelihood for that reduced form as usual in ML. As the web appendix formally elaborates, conditional likelihood functions for spatio-temporal-lag models, which treat first-period observations as predetermined, are straightforward extensions of static spatial-lag models’ likelihood functions, which, in turn, add only one mathematically and conceptually small complication (albeit a computationally intense one) to the likelihood functions for standard linear-normal models. We skip the derivation here (see the web appendix and Franzese & Hays 2006a, 2007c) and simply write the spatio-temporal-model conditional-likelihood in $(N \times 1)$ vector notation:

$$\text{Log } f_{y, y_{t-1}, \ldots, y_T} = -\frac{1}{2} N(T-1) \log(2\pi \sigma^2) + (T-1) \log|I - \rho W| - \frac{1}{2\sigma^2} \sum_{t=2}^{T} \varepsilon'_t \varepsilon_t,$$

where $\varepsilon_t = y_t - \rho W y_{t-1} - \varphi X_{t-1} - X_t \beta$

With this, estimation proceeds as usual, maximizing (9) over $\rho$, $\varphi$, $\beta$, and $\sigma^2$ for parameter estimates and estimating their variance-covariance as minus the inverse of the second-derivative (Hessian).

We stress the feasibility of empirical spatial and spatio-temporal analysis here rather than its great demands on specification, measurement, and sample size (more precisely: useful variation) for four reasons. First, the preceding sections have already offered that opposite emphasis. Second, those sections also stressed that ignoring interdependence when appreciably present is usually far worse than imperfectly including it; they described the conditions under which simpler, inconsistent estimators (S-OLS) may perform adequately; and they stressed that these challenges and difficulties apply equally regardless of research mode. That is—(1) the non-ignorability of interdependence, yet (2) the endogeneity entailed by its direct inclusion in empirical analysis, and then (3) that empirical redress of this simultaneity bias sets high demands for specification and measurement precision and
for much useful variation in observation—all these points apply equally to quantitative or qualitative empirical research. The scholar of CP/CPE has little choice. We cannot ignore interdependence; it will raise wide-ranging endogeneity; and our only recourse is therefore to model as precisely as possible and gather as much (and as usefully varying) empirical information as possible. Third, one increasingly popular alternative for addressing endogeneity in observational studies, propensity-score matching, is likely inapplicable given interdependence. Its core assumption, SUTVA: stable-unit-treatment-value assumption, means, inter alia, that no unit’s receipt, magnitude, or impact of treatment depends on any other unit’s receipt, magnitude, or impact of treatment. That is exactly negative the definition of interdependence, so, in a phrase: if interdependence, then not SUTVA. Fourth, and least conclusively, in part because most preliminarily, we have begun some sensitivity analyses of these methods (2004) and have not yet found measurement/specification error in $W$ to be as consequential as we had feared or as, for example, cross-spatial endogeneity does seem to be.\footnote{39}

V. Calculation, Interpretation, and Presentation of Spatio-Temporal Dynamics and Effects

Calculation, interpretation, and presentation of effects in empirical models with spatio-temporal interdependence, as in any model beyond those strictly linear-additive in variables and parameters, explicitly or implicitly,\footnote{40} involve more than simply considering coefficient estimates. Coefficients do not generally equate to effects outside that strictly linear-additive world. In empirical models with spatio-temporal dynamics, as in those with only temporal dynamics, the coefficients on explanatory variables give only the (often inherently unobservable) pre-dynamic impetuses to outcomes from changes in those variables. Here we discuss the spatio-temporal multipliers used in calculating the effects of counterfactual shocks in some unit(s) on its/their own outcomes and those of other units over time, i.e., spatio-temporal response-paths, or the long-run steady-state (LRSS) effects of such shocks, accounting both temporal and spatial dynamics. We also apply the delta method to derive analytically the asymptotic approximate standard errors for these response-path and LRSS estimates.

Calculating the cumulative LRSS spatio-temporal effects is most convenient working with the
spatio-temporal-lag model in \((\text{Nx}1)\) vector form:

\[
y_t = \rho W_N y_t + \phi y_{t-1} + X_t \beta + \varepsilon_t
\]

(10).

To find the long-run, steady-state, equilibrium (cumulative) level of \(y\), we set \(y_{t-1}\) equal to \(y\) in (10) and solve. This gives the steady-state effect, assuming stationarity\(^{41}\) and that the exogenous right-hand-side (RHS) terms, \(X\) and \(\varepsilon\), fix permanently to their hypothetical/counterfactual levels:\(^{42}\)

\[
y_t = \rho W_N y_t + \phi y_t + X_t \beta + \varepsilon_t = (\rho W_N + \phi I) y_t + X_t \beta + \varepsilon_t = [I_N - \rho W_N - \phi I_N]^{-1} (X_t \beta + \varepsilon_t)
\]

(11).

To offer standard-error estimates for these LRSS estimates, we use the \textit{delta method}. That gives a first-order Taylor-series linear-approximation to nonlinear (11) around the estimated parameter-values and determines the asymptotic variance of that linear approximation. Here, denote the \(i^{\text{th}}\) column of \(S\) as \(s_i\) and its estimate as \(\hat{s}_i\). The LRSS spatio-temporal effects of a permanent one-unit increase in \(\varepsilon_t\) in unit \(i\), for example, are then \(\hat{s}_i\), and the delta-method standard-errors of \(\hat{s}_i\) are:

\[
\nabla(\hat{s}_i) = \left[ \frac{\partial \hat{s}_i}{\partial \hat{\theta}} \right] \nabla(\hat{\theta}) \left[ \frac{\partial \hat{\theta}}{\partial \hat{\theta}} \right]^T, \text{ where } \hat{\theta} = [\hat{\rho} \quad \hat{\phi}]^T, \quad \left[ \frac{\partial \hat{s}_i}{\partial \hat{\rho}} \right] \equiv \left[ \frac{\partial \hat{s}_i}{\partial \hat{\phi}} \right]
\]

(12).

Analogously, the LRSS spatio-temporal effects of a permanent one-unit increase in explanatory variable \(k\) in country \(i\) are \(\hat{s}_i \hat{\beta}_k\), with delta-method standard-errors of:

\[
\nabla(\hat{s}_i \hat{\beta}_k) = \left[ \frac{\partial \hat{s}_i \hat{\beta}_k}{\partial \hat{\theta}} \right] \nabla(\hat{\theta}) \left[ \frac{\partial \hat{\theta}}{\partial \hat{\theta}} \right]^T, \text{ where } \hat{\theta} = [\hat{\rho} \quad \hat{\phi} \quad \hat{\beta}_k]^T, \quad \left[ \frac{\partial \hat{s}_i \hat{\beta}_k}{\partial \hat{\rho}} \right] \equiv \left[ \frac{\partial \hat{s}_i \hat{\beta}_k}{\partial \hat{\phi}} \right]
\]

(13).

The spatio-temporal response-path of the \(\text{N}x\text{I}\) vector of unit outcomes, \(y_t\), to some counterfactual
path of the exogenous RHS terms, $X$ and $\varepsilon$, can be traced by rearranging (10) to isolate $y_t$ on the left:

$$y_t = \left(1 - \rho W_N\right)^{-1} \left\{ \varphi y_{t-1} + X \beta + \varepsilon_r \right\} = S_2 \left\{ \varphi y_{t-1} + X \beta + \varepsilon_r \right\}$$

(14).

This formula gives the response-paths of all units $\{i\}$ to hypothetical shocks to $X$ or $\varepsilon$ in any unit(s) $\{j\}$, including a shock in $\{i\}$ itself/theirsehms, by inserting those counterfactual shocks in $X, \beta + \varepsilon_{i_1}$ in the row(s) corresponding to $\{j\}$. To calculate marginal spatio-temporal effects (non-cumulative) or plot the over-time path of the effect of a permanent one-unit change in an explanatory variable (cumulative), and their standard errors, working with the entire $NT \times NT$ matrix is easier. Redefine $S_1$ in (11) as $S_3 = \left[I - \rho W_N^T - \varphi M_{NT}^T\right]^{-1}$ and proceed as before. Web appendix material includes the spreadsheet, perhaps useful as a template, in which we calculate such spatio-temporally dynamic and LRSS effects in the substantive interpretation and presentation of our empirical reanalysis below.

**VI. Internal vs. External Determinants of Fiscal Policy: A Reanalysis of Swank & Steinmo**

We explained above (and showed elsewhere) how empirical specifications that omit spatial lags assume zero interdependence by construction and that this induces omitted-variable bias that inflates estimates of the effects of non-spatial model-components. In the present substantive context, this means most extant studies of globalization, having neglected spatial lags, have likely overestimated the role of domestic and exogenous-external conditions while preventing any globalization-induced interdependence from manifesting empirically. Conversely, we also explained how (and previously showed that) OLS regression estimates of models including spatial lags, which have become more common lately among scholars of globalization and diffusion, greatly improve upon previous non-spatial models but also suffer simultaneity biases that will tend to inflate interdependence-strength estimates at the expense of domestic and exogenous-external explanators. Estimation by S-ML of the spatio-temporal-lag model as described above effectively redresses both issues. Lastly, we showed how to calculate and present the spatio-temporally dynamic effects estimated in such an approach, so next we provide example of all this in reanalyzing the capital-tax regressions from Swank & Steinmo.
(2002), taking potential strategic policy-interdependence across countries into account.

Swank & Steinmo (2002) stress domestic factors—especially budgetary dynamics, public-sector debt, and macroeconomic performance—in their noteworthy study of tax-policy reform in OECD countries. They also find some external factors important, namely a country’s capital-account and trade openness. However, all their models omit spatial lags, thereby assuming country’s responses to changing internal or external political-economic conditions to be independent. Perhaps as a result, some findings seem unintuitive. Capital mobility and trade exposure reduce marginal statutory, but not effective, capital-tax-rates, and capital mobility reduces effective labor, but not capital, tax-rates. Swank & Steinmo suggest policymakers may combine statutory-rate cuts with eliminating some investment incentives, leaving effective tax-burdens static, but why this should achieve any political or economic effect is unclear. They suggest mobile capital may yield lower effective labor-tax-rates because labor taxes raise nonwage costs, eroding profits, but this would apply at least as strongly to capital taxes. Finally, they report panel-corrected standard-errors (PCSE), as has become standard practice for TSCS data in CP/CPE. PCSE implicitly recognizes spatial correlation, if not necessarily interdependence, in “correcting” standard errors, but it is treated as nuisance to correct rather than as potentially further evidence of external effects on tax policy. Swank and Steinmo conclude that their results “are consistent with the argument that, while internationalization has influenced the shift in tax-policy content, the combined effect of statutory tax-rate cuts and base-broadening reductions in investment incentives has left the effective tax burden on capital largely unchanged.” In relegating spatial correlation to adjusting standard errors, the spatial-nuisance approach abets such conclusions because any actual interdependence in the data is, in a cliché, “out of sight, out of mind.”

Swank (2006) greatly advanced this agenda, focusing squarely on spatial interdependence in tax policy. He estimates several spatio-temporal-lag models with spatial-weights, $w_{ij}$, specified to reflect three possible pathways: competition for foreign direct investment (FDI), policy learning, and social emulation. The first $W$ weighs equally (i.e., it averages) all $j \neq i$ countries in the sample. The second
weighs $j$ by the strength of $i$’s and $j$’s competition for capital, measuring that by total dyadic trade- and FDI-flows and the correlation of their direct-investment portfolios. The third gives positive $w_{ij}$ for countries in the same family of nations (as defined therein) and $w_{ij}=0$ otherwise. However, he finds support only for a fourth spatial-lag structure in which U.S. capital-tax-policy alone influences other countries’ capital-tax reforms—the U.S. as unmoved mover—with this effect being conditional on a country’s domestic politics, production regime, and economic integration with the U.S.

These are significant advances, but others occur to us as well. First, Swank ignores geographic proximity, which plays an important role in inter-jurisdictional competition, including for FDI, via human and capital migration directly but also, often more strongly, through third-party effects. As we noted in a labor-market-policy context (2006b), economic-interdependence effects incur strongly at borders. This derives, in part, from the tendency of firms to cluster operations around and across borders to minimize transport and related costs while capitalizing maximally on legal-institutional, especially tax-system, discontinuities at borders. Also, recent research in economics (e.g., Blonigen et al. 2004, Abreu & Melendez 2006, Guerin 2006) finds that multinational enterprises (MNE’s) use host countries as export platforms to nearby markets, again suggesting a major role for contiguity and geographic proximity in shaping which countries compete for FDI. Much of FDI to Ireland, for instance, goes to produce goods for export to continental Europe. Ireland and Britain thus compete not only for each other’s capital but also for FDI from third countries as, e.g., U.S. MNE’s may see Ireland and Britain as substitutable bases for export to continental, especially Benelux and French, markets. Portugal and Spain likely compete similarly; Canada competes with the U.S. for FDI from third countries in a way that Germany, e.g., does not; etc. Policy in one jurisdiction thus attracts or repels FDI in bordering jurisdictions, and so bordering countries’ policymaking will be especially interdependent. Additionally, spatial-weights based on borders have stronger claim to exogeneity than would weights based on FDI or trade flows, e.g., on which taxation likely has sizable effect.43

Second, Swank uses the strategy of time-lagged spatial-lags described above. As we discussed, if
interdependence incurs within an observational period, which, as also discussed, seems very likely in capital-tax competition, this strategy incurs (likely positive) simultaneity bias. It also misses within-period action, which would instead favor underestimating interdependence-strength. We apply the S-ML estimator sketched above, using a \textit{contemporaneous} binary-contiguity spatial-lag described below, and find strong evidence of within-period spatial interdependence in capital-tax policy based on contiguity. We then show how to interpret and present such spatio-temporal-effect estimates.

[Table 1 Here]

We focus on the capital- and labor-tax-rate results in Swank & Steinmo’s Table 2 (pp. 653-4). Their sample covers 195 observations from 13 countries, 1981-95. We add a spatial lag to their first-order temporal-lag model, yielding a specification like generic model (8) above. We calculated our spatial lag, $Wy$, using a standardized \textit{binary contiguity-weights matrix} which begins by coding $w_{ij}=1$ for countries $i$ and $j$ that share a border and $w_{ij}=0$ for countries that do not border (except we code France, Belgium, and the Netherlands as bordering Britain). Table 1 lists the countries and their neighbors. We then \textit{row-standardize} (as is standard in spatial-econometrics) the resulting matrix by dividing each element by its row’s sum, making $Wy$ the simple average of $y$ in $i$’s \textit{neighbors}.

[Table 2 Here]

Table 2 presents the original results and our reanalyses including the spatial lag. We report two sets of estimates for each tax rate, one for a model with both unit (country) and period (year) fixed-effects and one for a model with unit fixed-effects only. In sum, we find very differently regarding the importance of external factors, especially interdependence, for capital taxes. Among external factors, the non-spatial model found statistically significant effects only of capital-account openness, only on labor taxes. In the reanalyses, contrarily, spatial-lag-coefficient estimates suggest positive interdependence in all models, and substantively and statistically significantly so in capital taxes. Effective capital-tax-rates in one country statistically significantly impinge upon effective capital-tax-rates in others. Moreover, some coefficients on domestic variables that the non-spatial model
found substantively and statistically significant are smaller and insignificant in the spatio-temporal model, notably the elderly population and Christian-Democratic government (domestic conditions that therefore must cluster spatially). Thus, as we expected, non-spatial analysis of international tax-competition understated interdependence strength and overestimated some domestic factors’ roles. The labor-tax-rate estimates provide stark contrast. In neither case does the spatial-lag coefficient achieve statistical significance. Not surprisingly then, our spatial-lag-model estimates, particularly for the one including unit and period fixed-effects, are almost identical to Swank and Steinmo’s non-spatial-model estimates. Strategic policy-interdependence in labor taxation is weaker or absent. This result is intuitive and consistent with Franzese & Mosher’s (2002) arguments regarding the centrality of liquid-capital mobility in producing tax-competition. Workers are far less mobile than capital, so we would expect to find far less evidence of strategic policy interdependence in labor taxes.

Table 3 gives estimates of the spatial effects of counterfactual shocks to structural unemployment in eleven sample countries. The cells report estimated effects of unit increases in column-country structural-unemployment on row-country capital-tax-rates. The first number is the estimated first-period effect (direct effect plus spatial feedback), calculated using (14). For example, the immediate spatial effect (i.e., post-spatial but pre-temporal dynamics) of a unit increase in German structural employment on all thirteen countries is $\mathbf{s}_6\beta_5$, where $\mathbf{s}_6$ is the sixth column of $\mathbf{S}$ (Germany’s column in the spatial-multiplier) as defined in (14) and $\beta_5$ is the fifth row of the column-vector $\beta$ (structural unemployment is $x_5$). The second number is the standard error of this estimate, from (13) with $i=6$, $k=5$; and the last number is the estimated LRSS effect of a permanent unit-increase, from (11). For instance, we estimate a unit permanent increase in German structural unemployment produces a LRSS 7%-reduction in Germany’s capital-tax rate, which, along the way, induces France to lower its LRSS capital-tax rate by almost 1.4%. We can also effectively express a column of these estimates, say the fifth, again giving the first-period and the LRSS responses to a one-unit increase in German
structural-unemployment across all the countries, chorographically in a pair of maps as in Figure 2.

[Figure 2 Here]

Figure 3 and Figure 4 present temporal response paths to this counterfactual shock to German structural unemployment. We calculate each using the $i^{th}$ column of $S_i = [I_{NT} - \rho W_{NT} - \phi M_{NT}]^{-1}$ times $\beta_k$. Figure 3 gives the over-time marginal-response (year-on-year) in Germany’s own capital-tax-rate, including all spatial-feedback, with standard-error bands reflecting a 90% confidence interval. The cumulative effect after 15 periods is -6.523, just over 90% of the LRSS effect. Figure 4 plots the marginal first-order spatial-effects from a one-unit increase in German structural-unemployment on French capital-tax rates. An increase in German structural unemployment leads to a decrease in German capital-tax-rates, and this, in turn, produces a decrease in French capital-tax-rates. Roughly 68% of the steady state effect (-0.943/-1.395) is felt in the first 15 periods after the shock.

[Figure 3 and Figure 4 Here]

VII. Conclusion

Does international economic integration (i.e., globalization) constrain national governments in their attempt to redistribute income, risk, and opportunity through tax-and-expenditure policy? In this paper, we have shown that, in overlooking the degree and manner to/in which fiscal policies correlate spatially (i.e., across countries), previous attempts to answer this and related questions empirically have missed important evidence of globalization’s appreciable influence on domestic policymaking. We have shown formally and generally how positive and negative cross-jurisdictional externalities of policies induce, respectively, negative and positive strategic interdependence of domestic policies. Globalization and the implied heightened competition for capital therefore clearly imply capital-tax policies in one country will be influenced by those of its “neighbors.” Previous regression models that ignored the policy interdependence that globalization implies were therefore seriously misspecified and likely subject to omitted-variable bias that inflated their estimates of domestic and exogenous-external factors’ impacts while effectively preventing any empirical
manifestation of globalization effects via interdependence. We showed how to model such strategic policy-interdependence with spatial lags, discussed some crucial issues in the specification and estimation of such models and drawing valid empirical inferences from their estimates, and offered some suggestions on effective presentation of the spatio-temporally dynamic effect-estimates yielded by these models. We then reanalyzed Swank and Steinmo’s (2002) influential study of OECD tax-reform to illustrate the specification, estimation, and presentation of the spatial-lag models that can reflect more accurately the substance and theory of globalization and interdependence. In that re-analysis, we discovered that capital-tax-rate policies are substantively and statistically significantly interdependent, and thus that previous estimates do indeed seem to have been misleading in the ways our analysis would suggest. Labor being far less mobile across jurisdictions, we also found, intuitively, far less sign of significant strategic policy-interdependence in labor tax-rates and thus no such appreciable biases in previously reported results on that policy dimension.
REFERENCES


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Table 1: Sample Countries and their “Neighbors”

<table>
<thead>
<tr>
<th>Country</th>
<th>Neighbors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>None</td>
</tr>
<tr>
<td>Belgium</td>
<td>France, Germany, Netherlands, UK</td>
</tr>
<tr>
<td>Canada</td>
<td>US</td>
</tr>
<tr>
<td>Finland</td>
<td>Norway, Sweden</td>
</tr>
<tr>
<td>France</td>
<td>Belgium, Germany, Italy, UK</td>
</tr>
<tr>
<td>Germany</td>
<td>Belgium, France, Netherlands</td>
</tr>
<tr>
<td>Italy</td>
<td>France</td>
</tr>
<tr>
<td>Japan</td>
<td>None</td>
</tr>
<tr>
<td>Netherlands</td>
<td>Belgium, Germany, UK</td>
</tr>
<tr>
<td>Norway</td>
<td>Finland, Sweden</td>
</tr>
<tr>
<td>Sweden</td>
<td>Finland, Norway</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>Belgium, France, Netherlands</td>
</tr>
<tr>
<td>United States</td>
<td>Canada</td>
</tr>
</tbody>
</table>
Table 2: Reanalysis of Swank & Steinmo (2002, Appendix Table 2)

<table>
<thead>
<tr>
<th></th>
<th>Effective Tax Rate on Capital</th>
<th>Effective Tax Rate on Labor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Swank &amp; Steinmo</td>
<td>Reanalysis (1)</td>
</tr>
<tr>
<td>Temporal Lag</td>
<td>0.809**</td>
<td>0.808** (0.05)</td>
</tr>
<tr>
<td>Spatial Lag</td>
<td>0.104* (0.054)</td>
<td>0.126** (0.054)</td>
</tr>
<tr>
<td>Liberalization</td>
<td>1.146 (0.054)</td>
<td>1.235* (0.725)</td>
</tr>
<tr>
<td>Trade</td>
<td>-0.018 (0.064)</td>
<td>0.009 (0.061)</td>
</tr>
<tr>
<td>Structural Unemployment</td>
<td>-1.147** (0.306)</td>
<td>-1.218** (0.283)</td>
</tr>
<tr>
<td>Public Sector Debt</td>
<td>0.089** (0.036)</td>
<td>0.099** (0.032)</td>
</tr>
<tr>
<td>Elderly Population</td>
<td>1.264** (0.615)</td>
<td>1.011 (0.481)</td>
</tr>
<tr>
<td>Growth</td>
<td>0.230* (0.151)</td>
<td>0.242 (0.147)</td>
</tr>
<tr>
<td>% Change in Profits</td>
<td>0.127** (0.055)</td>
<td>0.136** (0.054)</td>
</tr>
<tr>
<td>Domestic Investment</td>
<td>0.066 (0.055)</td>
<td>0.045 (0.049)</td>
</tr>
<tr>
<td>Inflation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unemployment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left Government</td>
<td>0.018** (0.01)</td>
<td>0.018* (0.01)</td>
</tr>
<tr>
<td>Christian Democratic Government</td>
<td>0.041** (0.028)</td>
<td>0.035 (0.026)</td>
</tr>
<tr>
<td>Fixed Effects: R²</td>
<td>Ctry, Yr .928</td>
<td>Ctry, Yr¹ .922</td>
</tr>
</tbody>
</table>

Notes: Parentheses contain standard errors. **, * = significant at 5%, 10% level, respectively. ¹=Biannual period effects.
The second number is that estimate’s standard error. The final number is the estimated long-run steady-state effect. Australia and Japan are excluded because they have no neighbors in the sample. *Significant at the 5% Level; **Significant at the 10% Level.

<table>
<thead>
<tr>
<th></th>
<th>BEL</th>
<th>CAN</th>
<th>FIN</th>
<th>FRA</th>
<th>GER</th>
<th>ITA</th>
<th>NTH</th>
<th>NOR</th>
<th>SWE</th>
<th>GBR</th>
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<tr>
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<tr>
<td></td>
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<tr>
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<td>-1.23**</td>
<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
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<td>-1.23**</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
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<td>-0.032</td>
<td>-0.003</td>
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<tr>
<td></td>
<td>0.021</td>
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<td>0.018</td>
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<td>0.019</td>
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<tr>
<td>GER</td>
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<td>-7.643</td>
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<td>-0.731</td>
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<td>0</td>
<td>-1.395</td>
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<tr>
<td>ITA</td>
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<td>0</td>
<td>0.004</td>
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<tr>
<td>NTH</td>
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<td>-1.221**</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-0.003</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>0.04</td>
<td>0</td>
<td>0</td>
<td>0.073</td>
<td>0.004</td>
<td>0.306</td>
<td>0.001</td>
<td>0</td>
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<tr>
<td>NOR</td>
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<tr>
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<td>-1.222**</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>USA</td>
<td>0</td>
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<td>-0.067</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-1.225**</td>
<td>0</td>
<td>0</td>
<td>-0.067</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 3: Short-Run and Steady-State Spatial Effects from a Shock to Structural Unemployment
Figure 1: Capital-Tax Policy Reaction-Functions

$T(e^p, \tau_k^*)$

$T(e_0^p, \tau_k^*)$

$T^*(e^p, \tau_k)$
Figure 2: Map of First-Period and Long-Run-Steady-State Effects of Permanent 1-Unit Increase in German Structural Unemployment on Capital-Tax Rates across the Sample
Figure 3: Spatio-Temporal Effects on the German Capital-Tax-Rate from a Permanent One-Unit Counterfactual Positive Shock to Structural Unemployment in Germany (with a 90% C.I.)

Cumulative 15-Period Effect: -6.523
Figure 4: Spatio-Temporal Effects on the French Capital-Tax-Rate from a Permanent One-Unit Counterfactual Positive Shock to Structural Unemployment in Germany (with a 90% C.I.)

Cumulative 15-Period Effect: -.943
NOTES

1 Conceptually, the terms diffusion and interdependence seem subtly distinct in some literatures and synonymous in others. The concepts overlap, and care in making and maintaining distinctions is not always evident. For us here, interdependence will refer to contexts in which the outcomes of interest (i.e., dependent variables) in some units of analysis (e.g., countries) directly affect outcomes in others. Such interdependence may arise by myriad mechanisms, some of which must involve direct contact between the units involved (or of elements therein, e.g., citizens of countries) but others do not necessarily. Economic competition, e.g., does not require direct exchange between units to induce interdependence. Diffusion here will refer to the patterns and paths across space (and usually time) by which outcomes spread across units. It, too, may occur by many mechanisms, but patterns of spatial diffusion may appear without any direct effect from outcomes in some units to those in others, perhaps via spatial correlation in domestic or exogenous-external conditions affecting units. Distinguishing these possibilities is the essence of Galton’s Problem (and ours).

2 A web appendix (www.umich.edu/~franzese/Publications.html) gives fuller reference lists for the literatures developing empirical spatial-analysis and applying spatial interdependence in substantive contexts. It also expands technical presentation of the methodological issues presented here.


4 E.g., Schneider & Ingram 1988 to Meseguer 2004 and Braun & Gilardi 2006 (see note 2).

5 E.g., Huckfeldt & Sprague 1991 to Lacombe & Shaughnessy 2007 (see note 2).

6 E.g., Shin & Agnew 2002 to Kayser 2007 (see note 2).

7 E.g., Goldenberg et al. 1986 to Cho & Gimpel 2007 (see note 2).

8 E.g., Murdoch & Sandler 2004 to Gleditsch 2007 (see note 2).


10 E.g., from McAdam & Rucht 1993 to Swaroop & Morenoff 2006 (see note 2).

11 At least from Eising 2002 to Brune & Guisinger 2007 (see note 2).
12 Indeed, quite probably: *All of International Politics*…, as Gleditsch’s (2002) title has it.

13 To our own list (Franzese & Hays 2003, 2006b, 2007ab, 2008a), we could easily add many dozens more, e.g., from Genschel 2002 to Mukherjee & Singer 2007 (see note 2).

14 What is “learned” may be objective or subjective, true/correct or false/incorrect, and may regard politics, economics, sociology, or any other aspect of the options that shapes their appeal to actors.

15 To find $i$’s optimal policy, maximize $W^i$ with respect to $p_i$, taking $p_j$ as given (fixed); i.e., set $\frac{\partial W^i}{\partial p_i} = 0$, and solve for $p_i^*$ as a function of $p_j$. (Then verify that the second derivative is negative).

16 We eschew the terms *race to the bottom* (or *top*) and *convergence* because these competitive races need not foster convergence to top, bottom, or mean, and could spur divergence (see below and, for related further discussion of the observable regarding convergence, Plümper & Schneider 2006).

17 Unskilled labor is usually relatively mobile within (national) jurisdictions but highly immobile across borders, especially those delineating strongly differentiated ethno-linguistic, religio-cultural societies. Some skilled-labor works in highly specialized activities, limiting mobility of any kind; other types, some *human capitalists*, e.g., may be relatively mobile across jurisdictions.

18 See Franzese (2003) for a more-complete review of Swank (2002). Again, however, Swank’s later work (2006) and our own (2003, 2004, 2006a, 2007ab and below) properly specifies the effect of globalization on tax rates as based in interdependence, modifying these conclusions considerably, finding much stronger evidence for constraint on domestic autonomy from capital mobility.

19 Moreover, such competitive races would unfold regardless and independent of the efficiency of those tax systems or of the public policies they support, and zero offers no inherent *bottom* to these tax-cut races. In the competition for liquid portfolio-capital specifically, governments always have incentives to cut taxes further, perhaps deep into subsidy; only their abilities to tax other less liquid and/or mobile assets and to borrow limit (in internationally interdependent manner) these races.

20 These reaction-functions could slope positively or negatively because, while higher foreign tax-rates lure capital into the domestic economy, the increased tax-base may allow domestic policymakers to lower rates or, instead, to raise rates given the reduced elasticity of this base.

21 In later statistical analyses, the stochastic component, $\epsilon_{it}$, might be allowed to exhibit spatial
correlation, but this correlation would be treated as nuisance either to be corrected by Parks’ FGLS procedure or, post-Beck-&-Katz (1995, 1996), to require adjustment to standard-errors (PCSE).

22 Again, the random component, \( e_{it} \), may exhibit spatial correlation—i.e., spatial correlation distinct from that induced by exposure to the common shocks—but such correlation was treated as nuisance to be ‘corrected’ by Parks procedure (FGLS) or, later, to require adjusted standard-errors (PCSE).

23 Differencing (in)dependent variable(s) thusly controls for global conditions in that (those) variable but constrains coefficient(s) to be -1 (minus those on corresponding domestic independent variables).

24 Kronecker product, \( d \otimes s \), multiplies the entire \( k_d \times 1 \) vector of domestic factors, \( d \), with each term of the \( k_s \times 1 \) vector of exogenous-external shocks, \( s \), yielding a \( (k_d k_s) \times 1 \) vector of interactions with coefficients, \( \beta_{sd} \). This is the most-general linear-interactive expression of context-conditionality.

25 Domestic institutional, structural, or contextual factors might include union density, industrial structure, or electoral competitiveness. Exogenous-external conditions might include technological, shipping, or financial progress.

26 Once again, any spatial correlation distinct from that induced by the context-conditioned responses to common shocks was relegated to FGLS or PCSE corrections. In some of these empirical models, controls for common shocks or other conditions abroad include dependent-variable conditions abroad. However, these spatial lags are seen solely as nuisance controls proxying for exogenous-external conditions, and their implied interdependence and spatial dynamics are unnoticed.

27 One could also allow spatial error-correlation to remain for address by FGLS or PCSE strategies, but optimal here as previously will be to model interdependence and correlation directly if possible.

28 Sir Francis Galton (1889), commenting on a presentation (in 1888) by Sir Edward Tylor to the Royal Anthropological Society in which Tylor suggested a causal correlation of societal complexity to certain marriage and heritance customs, argued that these customs could not be viewed as independent outcomes until the possibility that they “had derived from a common source, so that they were duplicate copies of the same original” was rejected. The web appendix elaborates.

29 Methodologically, spatial-statistics and spatial-econometrics approaches to spatial analysis differ (Anselin 2006). Crudely, and perhaps unfairly, the distinction corresponds to nuisance vs. substance.
and spatial-correlation vs. spatial-interdependence. The web appendix elaborates (see note 2).

30 Nonrectangular or missing data are manageable, but assuming full-rectangularity eases exposition.

31 In detail, for non-time-varying interdependence-patterns, this W matrix can be expressed as a Kronecker product (see note 24) of a $T \times T$ identity matrix and the $N \times N$ weights matrix $(I_T \otimes W_N)$, with the elements $w_{ij}$ of $W_N$ reflecting the relative connectivity from unit j to i as described above.

32 Alternative distributions of $\varepsilon$ are possible but add complication without illumination.

33 Again, qualitative strategies that failed to consider interdependence or that considered it but failed to redress properly the simultaneity of the observed phenomena would suffer the same biases.

34 Interest in strategies for parameterizing W in estimable models like (8) is great, but the literature has offered little progress to date.

35 See especially Franzese & Hays (2007c, 2008a) regarding S-ML estimation; these correct some misleading preliminary conclusions from the earlier work on that estimator.

36 The web appendix and previous work (Franzese & Hays 2004, 2006a, 2007cd, 2008ab) elaborate.

37 LeSage’s MatLab code is available at www.spatial-econometrics.com. One crucial correction: line 183 of sar.m references the wrong element of the variance-covariance matrix as the variance of $\hat{\rho}$.

Our data and MatLab code for replication, our prototype Stata code, and our Excel spreadsheets are available at www.umich.edu/~franzese/Publications under the respective articles, including this one.

38 Elhorst (2001:128) shows the likelihood function for the spatio-temporal lag model retains the bias even in this best case if the first observation is stochastic (if initial conditions are random rather than fixed across repeated samples). Franzese & Hays (2006a, 2007c, 2008ab) elaborate. (See note 2.)

39 This adds to arguments in note 43 favoring a geographic-proximity basis for W for our purposes.

40 E.g., the familiar linear-interaction models are explicitly nonlinear in variables though linear-additive in parameters; logit/probit models are explicitly nonlinear in variables and parameters; and temporally or spatially dynamic models are implicitly nonlinear in parameters and variables.

41 Assuming row-standardized W, spatio-temporal stationarity requires $|\phi + \rho| < 1$ (see note 2).

42 Given stationarity, the LRSS of any temporary shock is zero. Conceptually useful is to decompose $\varepsilon$ into fixed $\eta$ plus stochastic $\gamma_t$ and then to consider permanent shocks to $\varepsilon$ as occurring in $\eta$.
We do not intend by these arguments to suggest alternative connectivity matrices, based on dyadic FDI, trade, or financial flows, or on similarity or diversity in flows to third parties or in production, export/import, or asset/liability profiles, might not also capture important bases on which countries compete for capital. These seem substantively quite likely. Moreover, from an expository view, they would have better-illustrated two key points: (1) connectivity matrices must be soundly theoretically motivated, precisely measured, and substantively powerful, especially since empirical analyses tend to understate spatial interdependence when spatial model-components are relatively poorly specified, and (2) proximity/connectivity of units, and so $W$, need neither be symmetric nor geographically determined. (Our row-standardized contiguity-matrices are substantively motivated, etc., as argued in the text, and asymmetric, because bordering $i$ and $j$ can have differing numbers of other bordering units, but these features may be less obvious.) However, as noted, recent research finds contiguity and proximity to be extremely strong determinants of who competed with whom for capital; Swank (2006) already explored some of these alternatives with rather discouraging, although inconclusive, results; and $w_{ij}$ based on economic transactions, flows (FDI, trade, financial) or stocks (production, export/import, asset-portfolio profiles) are especially likely to be endogenous to fiscal policy.

The included unit and period fixed-effects proved necessary for stationarity (see note 41).

First-order spatial-effects incur to neighbors, including all feedback through all units; second-order spatial-effects would refer to the effects on neighbors’ neighbors (e.g., of Germany on Italy).