Broll, Udo; Roldán-Ponce, Antonio; Wahl, Jack E.

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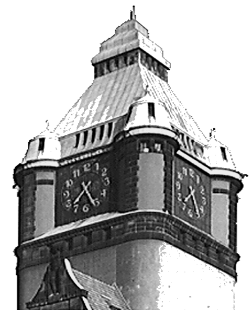

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UDO BROLL

ANTONIO ROLDÁN-PONCE

JACK E. WAHL

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Address of the author(s):

Udo Broll
Technische Universität Dresden
Faculty of Business and Economics
01062 Dresden
Germany

e-mail : udo.broll@tu-dresden.de

Antonio Roldán-Ponce
Technische Universität Dresden, Dresden, Germany
Universidad Autonoma de Madrid, Madrid, Spain

e-mail : antonio.roldan-ponce@tu-dresden.de

Jack E. Wahl
Technische Universität Dortmund
Department of Finance
44227 Dortmund
Germany

Editors:

Faculty of Business and Economics

Internet:

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Andreas Buehn
e-mail: wpeconomics@mailbox.tu-dresden.de

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Spatial Allocation of Capital: The Role of Risk Preferences

Udo Broll
Technische Universität Dresden
Faculty of Business and Economics
01062 Dresden
udo.broll@tu-dresden.de

Antonio Roldán-Ponce
Technische Universität Dresden, Dresden, Germany
Universidad Autonoma de Madrid, Madrid, Spain
antonio.roldan-ponce@tu-dresden.de

Jack E. Wahl
Technische Universtät Dortmund
Department of Finance
44227 Dortmund

Abstract:

This paper considers a model of spatial allocation of investment capital under uncertainty. We demonstrate that the spatial concentration of economic activity depends upon properties of risk preferences deeper than risk aversion. The degree of so-called relative prudence unambiguously decides whether or not the diversi cation of income risk favours the geographic dispersion of economic activity. In our framework we relate risk diversi cation with economic integration. Then there exists risk preferences so that spatial concentration of industry and capital is not a ected by the degree of economic integration or segmentation of the regions. We also study the impact of net return regressibility upon spatial allocation.

JEL-Classification: D81, R12, R30, R38

Keywords: spatial allocation, inter-regional disparity, risk aversion, prudence, regression

1. Introduction

The literature in spatial and regional economics has developed a fundamental interest in the allocation of resources and the role of agglomeration and diversification of capital to regions or countries.[1] In particular, economic development aspects of capital agglomeration (OECD 2005), the location decisions of international firms (Pontes (2005), and the economics of the induction of a clustering process have been subject to thorough investigation stressing, among other things, the importance of spatial economies of scale and scope (Fujita *et al.* (1999), OECD (2007a), Baldwin and Wyplosz (2009)).

Dispersion forces, e.g. the 'local competition' force, favour the geographic dispersion of economic activity whereas agglomeration forces, e.g. 'market size' force, favour the geographic concentration. Uncertainty of regional returns on investments is also on the realm of spatial economics. Hence optimum spatial distribution of scarce resources and optimum decision on the location of firms' business activities are affected by a 'risk-diversification' force. That is, risk-averse firms are attracted to regions with higher expected net returns on investment and lower return risk. In addition, the correlation of random regional returns is important and measures the risk-diversification potential of inter-regional activities of firms (Chiang (2009), OECD (2007b)).

In order to identify the (risk-)diversification force as a dispersion or an agglomeration force we need a deeper inspection of risk preferences. Our approach reveals that relative prudence and the elasticity of risk aversion with respect to changes in income risk, respectively, allows for a closer inspection of the diversification force. The degree of relative prudence determines whether or not diversification acts as a pro-concentration or anti-concentration force. In general, it is not true that diversification tends to disperse economic activities of firms. Income and substitution elasticities matter and determine the magnitude of relative prudence. This fact may contribute to the explanation of disturbing empirical results in spatial econometrics (see, e.g. Duranton (2008)).

The study is organised as follows: Section 2 presents our model of spatial allocation and discusses corner vs. interior solutions of optimum capital sharing over regions. In section 3 we state the condition for a non-symmetric regional capital allocation. Section 4 presents our main results. It relates the correlation of uncertain regional returns on investment to spatial allocation subject to the structure of risk preferences. The main theoretical contribution of the paper is the insight, that economic integration may well agglomerate investment capital rather than disperse it.

2. A Model of Spatial Allocation

A risk-averse firm, located in a spatial economy with two regions, has I units of capital endowment which would earn uncertain returns from investments in either region. Let $\tilde{c}_1$ and $\tilde{c}_2$ denote locational random costs of doing business in region 1 and 2, respectively. The random costs differential from location, $\tilde{\Delta} = \tilde{c}_2 - \tilde{c}_1$, is based, for example, on different land prices, productivities, business environment, industrial policy, regulations, fiscal and tax policies etc. which leads to random differences in regional net returns. We model business costs of the firm at the subnational level such that $(1 - \tilde{c}_i)R$ is retained as the uncertain net return per unit of investment in region $i\,(i = 1, 2)$, where R denotes gross return at the national level.

Random income of the firm, $\tilde{Y}$, comes from doing business in the regions, where s denotes spatial allocation of investment capital to region 1. Capital share $(1-s)$ goes to region 2. Hence the firm's future income is defined as:

$$\tilde{Y} = [(1-\tilde{c}_1)s + (1-\tilde{c}_2)(1-s)]RI. \tag{1}$$

Given some risk preferences, maximizing expected utility of income with respect to regional capital allocation s is to solve the following decision problem:

$$\max_s EU(\tilde{Y}), \tag{2}$$

where E represents the expectation operator. The von Neumann-Morgenstern utility function is thrice continuously differentiable: Marginal utility is positive, i.e. $\partial U/\partial Y = U' > 0$, and decreasing, i.e. $\partial U'/\partial Y = U'' < 0$, which means risk aversion. The derivative $\partial U''/\partial Y = U'''$ is not sign-constrained. Kimball (1990, 1993) associates this derivative with prudent behaviour.[2] Prudence becomes relevant when analysing diversification as an agglomeration or dispersion force in the economic theory of geography.

The first-order condition for optimum spatial allocation where the choice variable must be nonnegative requires:

$$EU'(\tilde{Y})\tilde{\Delta} \leq 0, \quad s \geq 0 \quad \text{and} \quad sEU'(\tilde{Y})\tilde{\Delta} = 0. \tag{3}$$

(i) Consider $s = 0$. If (positive) correlation of regional costs $\tilde{c}_1$ and $\tilde{c}_2$ does not exceed a critical level,[3] from income equation (1) we obtain:

$$\text{cov}(U'(Y), \tilde{\Delta})|_{s=0} = \text{cov}(U'[(1-\tilde{c}_2)RI], \tilde{\Delta}) \geq 0.$$

From optimum conditions (3) we get:

$$EU'(\tilde{Y})\tilde{\Delta} = EU'(\tilde{Y})E\tilde{\Delta} + \text{cov}(U'(\tilde{Y}), \tilde{\Delta}) \leq 0.$$

Hence the expected costs differential cannot be positive, in other words, $E\tilde{c}_2 \leq E\tilde{c}_1$, since marginal utility is positive. Therefore, a corner solution of perfect agglomeration in region 2 requires that region 1 has no expected regional costs advantage.[4]

(ii) Consider $s > 0$. Then the classical first-order condition must hold:

$$EU'(\tilde{Y})\tilde{\Delta} = 0. \tag{4}$$

Let us summerize our discussion as follows.

Proposition 1. Suppose there exists an expected regional costs advantage in favour of region 1, i.e. $E\tilde{c}_2 > E\tilde{c}_1$, and suppose an appropriately bounded positive correlation of regional costs. Then partial agglomeration/some dispersion occurs, i.e. $0 < s < 1$.

The *proof* follows from the above discussion.

Given that each location has its specific expected return, risk preferences play a pivotal role when one analyses the impact of return risk differences due to location upon spatial allocation of capital. In this context, distance is most important for the correlation of regional returns on investment. Large geographical distance may even result in negatively correlated net returns. Geography matters in the correlation of stock indexes (Fasnacht & Loubergé (2007)).

Suppose that regional policy calls for a harmonization of economic conditions of location. For example, tax harmonization is high on the political agenda of the European Union countries. With globalization in general, regional policy often wants the world to become "flatter" (Friedman (2007)). Then locational distance becomes less important and uncertain returns on investment are more positively correlated. Does this process lead to more agglomeration or more dispersion of capital in the regions? In other words, does risk diversification promote spatial concentration of economic activity or discourage such concentration?

New literature of economic geography leads potentially to surprising conclusions with respect to harmonization, for it takes explicitly into account agglomeration and dispersion forces (Brakman *et al.* (2008)).

We demonstrate that firms' risk preferences determine whether or not diversification is an agglomeration or dispersion force. Suppose risk preferences exhibit constant absolute risk aversion (CARA). If regional policy leads to more diversification opportunities in spatial allocation, then the diversification force can be seen as a dispersion force; economic activity becomes less concentrated over the regions (Broll *et al.* (2005)).

3. Perfect Dispersion of Capital Allocation

As an illustration of the aim of our investigation consider former Western and Eastern Germany and today's federal and local governments' regional economic policy. We observe many political initiatives intending to harmonize regional standard of living (Brakman *et al.* (2008)). What are the conditions under which firms have an incentive to diversify investments across regions?

Most important are locational differences in the costs from doing business. In order to pinpoint this insight we study the conditions for an even split of capital between region 1 and 2. Thereby we disregard the costs magnitude and focus on the difference of regional costs. For technical reasons we, therefore, introduce the following constraint.

Assumption (A1). Let $\mathrm{Prob}(\tilde{c} \leq \epsilon) = 1$, where $\tilde{c} = (\tilde{c}_1 + \tilde{c}_2)/2$.

In order to motivate and describe the meaning of assumption (A1) let us consider the following restatement of the firm's income equation (1):

$$\tilde{Y} = [(s - 1/2)\tilde{\Delta} + (1 - \tilde{c})]RI. \tag{5}$$

By using equation (5), let us differentiate expected utility of income with respect to allocation s to region 1. If we evaluate the result at point $s = \frac{1}{2}$, by including assumption (A1) we get

$$\begin{aligned} \left.\frac{\partial EU(\tilde{Y})}{\partial s}\right|_{s=\frac{1}{2}} &= EU'[(1-\tilde{c})RI]\tilde{\Delta}, \\ &\approx U'(RI)E\tilde{\Delta}. \end{aligned} \tag{6}$$

Hence spatial allocation is symmetric if and only if expected net returns do not differ locationally.

The following result reveals the importance of the costs differential between regions.

Proposition 2. Suppose assumption (A1) holds. If expected business costs are identical between regions, then allocative dispersion is perfect, i.e. $s = 1/2$. If expected business costs differ between regions, than the region with the lower expected costs gets the higher capital share.

Proof. From the first-order condition (4) we obtain

$$EU'(\tilde{Y})E\tilde{\Delta} = -\text{cov}(U'(\tilde{Y}), \tilde{\Delta}). \tag{7}$$

Since $U' > 0$ we get sign $E\tilde{\Delta} = -\text{sign}\,\text{cov}(U'(\tilde{Y}), \tilde{\Delta})$. Using assumption (A1), the definition of the firm's income (5) and the properties of the utility function we obtain $\text{sign}\,\text{cov}(U'(\tilde{Y}), \tilde{\Delta}) = -\text{sign}(s - 1/2)$. Therefore, $\text{sign}(s - 1/2) = \text{sign}\, E\tilde{\Delta} = \text{sign}(E\tilde{c}_2 - E\tilde{c}_1)$. This proves the claim.

$E\tilde{\Delta} > 0$ implies that there is an intrinsic bias in favour of allocating capital to region 1. From equation (7) we see that the magnitude of the asymmetry in spatial allocation also depends upon risk preferences and the assessment of the probability distribution of net returns.

4. Diversification Force and Risk Preferences

In the following we investigate on the interaction between spatial allocation of capital, geographical distance and risk preferences. Empirically, distance (Fasnacht & Loubergé (2007)) and segmentation of markets (Bekaert *et al.* (2007)) affect the correlation of regional returns on investment.

4.1. Regional Costs Correlation

There exist a diversification force in the economics of geography under uncertainty. Depending upon risk preferences this force becomes either a pro-concentration (agglomeration) force or an anti-concentration (dispersion) force. This insight will be demonstrated.

Suppose that tighter economic integration, e.g. tighter European integration, leads to more transparency of the economic conditions of specific locations. Then locational distance and segmentation of markets becomes less important. We presume that the correlation of regional net returns is inversely related to distance and the degree of segmentation. Other things being equal, this implies that the variance of the locational costs differential decreases if integration becomes tighter.[5]

In order to analyse how the correlation of uncertain locational costs affects spatial allocation via risk preferences we use a mean preserving spread/shrink in the relevant random variable, which is a well-known definition of increasing/decreasing risk (Rothschild & Stiglitz (1970)). The well-known expected utility approach leads to the concept of prudence (Kimball (1990)).

We introduce the following definitions.

Definitions. (i) Let $\tilde{\Delta}_k$ denote a mean preserving *shrink* of the costs differential $\tilde{\Delta}$. (ii) Let $P(Y) = \frac{U'''(Y)}{-U''(Y)}Y$ denote relative prudence.

The following result reports the relationship between the degree of agglomeration in spatial allocation, costs correlation as a diversification force and risk preferences.

Proposition 3. Be $E\tilde{\Delta} = E\tilde{\Delta}_k > 0$ and, therefore, $s > 1/2$. A mean preserving shrink in the costs differential leads to less inter-regional disparity in capital allocation if and only if relative prudence exceeds 2.

Remark: One may consider as a benchmark of the firm's utility function the generalized logarithmic utility function $U(Y) = Y + \gamma \ln Y$, $\gamma > 0$. This utility function exhibits $P(Y) = 2$ (Battermann *et al.* (2008)).

Proof. (1°) From Proposition 2 we have $\text{sign}(s - 1/2) = \text{sign}\, E\tilde{\Delta}$. Let $f(z) = zU'(z)$. Hence $f'(z) = U'(z) + zU''(z)$ and $f''(z) = 2U''(z) + zU'''(z)$. Rearranging terms yields $f''(z) = -U''(z)(P(z) - 2)$, where $P(z) = -zU'''(z)/U''(z)$. Since $U''(z) < 0$ we obtain $\text{sign} f''(z) = \text{sign}(P(z) - 2)$.
(2°) From the first-order condition (4) and definition (i) we obtain $EU'(\tilde{Y}_k)\tilde{\Delta}_k < (=) [>] 0$, where by Jensen's inequality the sign depends upon the convexity of the argument. Note that we consider a mean-preserving *shrink*, hence, convexity (linearity) [concavity] holds if and only if $P(Y) > (=)[<] 2$, since income increases with the costs differential. Therefore, $\text{sign}\, EU'(\tilde{Y}_k)\tilde{\Delta}_k = -\text{sign}(P(Y) - 2)$.
(3°) In order to satisfy the first-order condition, former optimum spatial allocation (before the shrink occured) must be adjusted. Therefore, s declines as a result of a mean preserving shrink if and only if $P(Y) > 2$. The claim follows.

Proposition 3 reveals that preferences of the firm play a pivotal role when one evaluates the diversification force upon spatial allocation. Regarding the allocation of resources over space and the location of economic activity risk preferences, more precisely the degree of relative prudence, determine whether or not the diversification force is a dispersion force, i.e. favours the geographic dispersion of industry and capital. Surpricingly, for some characteristic of preferences - deeper than risk aversion - the diversification force has to be seen as an agglomeration force.

To work out the economic intuition behind Proposition 3 we relate our finding to the framework of two-moment decision models (Meyer (1987)). This allows us to apply the notion of elasticity of risk aversion.

Corollary. Suppose a mean preserving shrink in the regional costs differential. Then (in)elastic risk aversion leads to dispersion (agglomeration) in spatial allocation. Spatial allocation is not affected by the diversification force if and only if risk preferences exhibit unit elasticity of risk aversion.

Proof. From the discussion above we obtain $\text{sign}(P(Y) - 2) = \text{sign}(\varepsilon - 1)$, where ε denotes the elasticity of risk aversion (Broll *et al.* (2006)).

The risk aversion elasticity with respect to changes in the standard deviation of uncertain income incorporates a substitution and income effect. The final effect of a correlation change on spatial allocation is unknown and depends on preferences. If substitution and income effect cancel out, the diversification force is neutral to spatial allocation.

4.2. Regional Costs Regression

There is a growing literature in the empirics of dispersion and agglomeration with various different approaches (Head & Mayer (2004)). It is common in the empirical literature of spatial economics to study economic effects of policy measures under the presumption that economic variables are related by some sophisticated regression (see, e.g., Fingleton (2008)).

To study the impact upon the regional share of capital of a (linear) correlation between locational costs of doing business we introduce the following straightforward regression.

Assumption (A2). Consider the regression specification of regional business costs: $\tilde{c}_1 = \alpha + \beta\tilde{c}_2 + \tilde{u}$, where $E(\tilde{u}|c_2) = 0$.

Remark: There exists a systematic relationship between uncertain locational costs $\tilde{c}_1$ and $\tilde{c}_2$. The linear relation is obscured by an uncorrelated noise $\tilde{u}$ with zero conditional mean. Note that $E(\tilde{u}|c_2) = 0$ implies $\text{cov}(\tilde{c}_2, \tilde{u}) = 0$, since $E\tilde{c}_2\tilde{u} = E[\tilde{c}_2 E(\tilde{u}|\tilde{c}_2)]$.

Definition. Let $A(Y) = \frac{-U''(Y)}{U'(Y)}$ and $A(Y)Y$ denote the Arrow-Pratt measure of absolute and relative risk aversion, respectively.

The following result reports how the agglomeration of investments reacts on costs regressibility given some risk preferences.

Proposition 4. Let $E\tilde{\Delta} > 0$ and, therefore, $s > 1/2$. Suppose the regression relationship strengthens such that the regression parameter β increases. Then the inter-regional disparity in capital allocation diminishes if the degree of relative risk aversion does not exceed unity.

Proof. Implicit differentiation of the first-order condition (4) leads to:

$$\text{sign}\frac{ds}{d\beta} = \text{sign}\, E\{A(\tilde{Y})\tilde{Y} - 1 - A(\tilde{Y})(1-\tilde{c}_2)RI\}U'(\tilde{Y})\tilde{c}_2. \qquad (8)$$

Since $A(Y)(1-c_2)RI > 0$, the overall term in brackets is negative if the level of relative risk aversion does not exceed unity. The claim follows.

Under our regressional condition and some specific risk preferences economic integration achieves more dispersed spatial allocation in the country. The reason is that, in the first place, an increase in regression parameter β decreases the locational costs differential in expected value. This makes dominant region 1 less attractive than region 2. On the other hand, diversification potentiality lessens since business costs are more correlated. Risk preferences have to exhibit a level of relative risk aversion below a critical level so that the net effect of more integrated or correlated regions leads to less agglomeration of capital investments.

Note, however, that according to empirical studies (see, e.g., Friend & Blume (1975)), coefficients of relative risk aversion are typically far in excess of unity. Hence, at some point, agglomeration of capital will occur, that is, the diversification force becomes and agglomeration force. The reason is that the firms' benefit from a lower business costs differential is overcompensated by the disutility of reduced diversification opportunities. This is in line with the empirical evidence of capital agglomeration in the OECD countries (OECD (2005)).

4.3. Comparison

In general, preferences determine whether or not the diversification force tends to disperse economic activity. In Proposition 3 we demonstrate that the degree of relative prudence is a necessary and sufficient magnitude to identify diversification as a dispersion force or an agglomeration force. No specific statistical assumptions - besides some basic regularity assumptions -

on the probability distribution of uncertain regional costs are introduced.

On the other hand, if we put some constraint on the stochastic properties of uncertain business costs, e.g. the regressibility of regional costs of Assumption (A2), less information about the preference structure - in our case the degree of relative risk aversion - has to be considered to derive a sufficient condition for our result.

Loosely speaking, there exist some trade-off between the preference and stochastic setting of assumptions in order to derive our findings. This fact may be important to evaluate empirical research in spatial economics.

5. Conclusion

The paper is concerned with spatial economics under uncertainty. The allocation of scarce resources over space is driven by so-called agglomeration and dispersion forces. Depending upon the structure of risk preferences we demonstrate whether or not the diversification force promotes or discourages spatial concentration of economic activity.

We consider risk-averse firms doing business under uncertain regional net returns on investments. One region is presumed to have an advantage in expected net returns, i.e. there is some inter-regional disparity of capital allocation. Uncertain regional net returns are (less than perfect positively) correlated and provide some diversification opportunity. We identify the Kimball-measure of relative prudence (or, the elasticity of risk aversion) as the entity that allows us to relate the diversification force to pro-concentration forces and anti-concentration forces, respectively. This theoretical insight should prove to be helpful in the empirics of spatial economics. The structure of risk preferences is a spatial fundamental.

Notes

[1] See, e.g., Krugman & Venables (1995), Brakman *et al.* (2001), Puga (2002), Pflüger (2004), Fujita (2005), Pflüger & Südekum (2008).

[2] Prudence $U'''(Y) > 0$ decribes convex marginal utility and, therefore, measures the firm's sensitivity to low income levels vs. high ones. Prudence is an important issue in many fields of economics and finance. For example, Machnes & Wong (2003) apply this measure in the theory of insurance.

[3] For example, with quadratic utility marginal utility is a linear function of income for the relevant range, i.e. $U'(Y) = a - bY > 0$, where $b > 0$. In this case the critical level of costs correlation is exceeded if $\text{cov}(\tilde{c}_1, \tilde{c}_2) > \text{var}(\tilde{c}_2)$, where cov and var denote the covariance and variance operator, respectively.

[4] A costs correlation too high may prevent firms to move to region 1, although there exists a costs advantage in this region, i.e. $E\tilde{c}_2 > E\tilde{c}_1$. This situation can be regarded as if high fixed costs of diversification were present. We obtain a corner solution, i.e. we have spatial concentration to region 2.

[5] Note that $\text{corr}[(1-\tilde{c}_1)R, (1-\tilde{c}_2)R] = \text{corr}(\tilde{c}_1, \tilde{c}_2)$, where corr denotes the correlation operator. Furthermore, $\text{var}(\tilde{c}_2 - \tilde{c}_1) = \text{var}(\tilde{c}_2) + \text{var}(\tilde{c}_1) - 2\,\text{corr}(\tilde{c}_1, \tilde{c}_2)\sqrt{\text{var}(\tilde{c}_1)\text{var}(\tilde{c}_2)}$.

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