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Article — Accepted Manuscript (Postprint)

Reversing the rural race to the bottom: an evolutionary model of neo-endogenous rural development

European Review of Agricultural Economics

Provided in Cooperation with:

Leibniz Institute of Agricultural Development in Transition Economies (IAMO), Halle (Saale)

Suggested Citation: Petrick, Martin (2013) : Reversing the rural race to the bottom: an evolutionary model of neo-endogenous rural development, European Review of Agricultural Economics, ISSN 1464-3618, Oxford University Press, Oxford, Vol. 40, Iss. 4, pp. 707-735, <https://doi.org/10.1093/erae/jbt019>

This Version is available at:

<https://hdl.handle.net/10419/155471>

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Reversing the Rural Race to the Bottom: An Evolutionary Model of Neo-endogenous Rural Development

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This version: 14 February 2017

Abstract

The article contributes to the understanding of neo-endogenous rural development from the perspective of evolutionary game theory. Rural development is modelled as the increasing realisation over time of gains from interaction by rural stakeholders. The model exhibits two dynamically stable equilibria, which depict declining and prospering regions. An external government authority stimulates neo-endogenous rural development by helping decentralised actors to coordinate on the superior of the two equilibria. This intervention may be possible and desirable without giving up the autonomy of local decision makers. Because initial conditions matter, outcomes cannot be planned or engineered from the outside.

Keywords: Rural governance, neo-endogenous rural development, evolutionary game theory, collective action.

JEL-codes: C73, R23, R58.

Acknowledgements

I am grateful to Doris Marquardt, Judith Möllers and Diana Traikova as well as two anonymous reviewers for helpful suggestions and comments. Many thanks also go to Frithjof Petrick for able assistance in programming the simulation model.

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model of neo-endogenous rural development. European Review of Agricultural
Economics 40 (4): 707-735* is available online at: <http://dx.doi.org/10.1093/erae/jbt019>

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Abstract

The article contributes to the understanding of neo-endogenous rural development from the perspective of evolutionary game theory. Rural development is modelled as the increasing realisation over time of gains from interaction by rural stakeholders. The model exhibits two dynamically stable equilibria, which depict declining and prospering regions. An external government authority stimulates neo-endogenous rural development by helping decentralised actors to coordinate on the superior of the two equilibria. This intervention may be possible and desirable without giving up the autonomy of local decision makers. Because initial conditions matter, outcomes cannot be planned or engineered from the outside.

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1 Introduction

In its widely acknowledged publication ‘The New Rural Paradigm’ (2006), the OECD identified a vicious circle characterising the economic situation in many rural regions of its member countries. The mutually reinforcing elements of this circle include a low population density, which leads to a lack of critical mass for services and infrastructure, which in turn implies lower rates of business creation. Fewer businesses result in fewer jobs, which induces out-migration and ageing, which again lowers the population density of a rural area, so that the circle is closed (see OECD, 2006: 24-37). A natural question that arises from this diagnosis is how the circle can be broken. The strategy advocated by the OECD is to enter a ‘New Rural Paradigm’, in which traditional agricultural sector policies are replaced by territorially-oriented rural policies. The programme LEADER of the European Union (EU) is one of the leading policy examples of the ‘New Paradigm’. It provides funding for area-based local strategies to induce rural development by innovative projects of resource valorisation, enhancing competitiveness, and networking. Strategies are supposed to emerge from bottom-up initiatives developed by local stakeholders.

The aim of this article is to contribute to the understanding and interpretation of LEADER-type policies from the perspective of evolutionary game theory. So far, the debate on what LEADER-type policies are, how they affect economic and social development processes, and where they are to be located in the social science of rural development has largely been dominated by sociologists, geographers, and rural planners (Furmankiewicz et al., 2009; Shucksmith, 2000; 2009). Ray (2006) aptly called this approach ‘neo-endogenous’, as it advocates development along a bottom-up trajectory. ‘Localities can effect change in their favour’, and need not become ‘victims of broad, exogenous, political and economic forces’ (Ray, 2006: 278). At the same time,

there is some type of intervention in the form of rural policies, ‘neo’ thus stressing the influence of the extralocal. Ray (2000) labelled LEADER both a modern and a post-modern form of intervention, stressing that the commitments made by the public were small in terms of financial volume, but that they allowed a surprising element of ‘anarchy’ in terms of latitude localities have in decision making. Böcher (2008) established the link between LEADER and the concept of regional governance, highlighting the self-governing responsibilities of regions, the co-operation of different types of actors, and the role of competition among regions. Various authors have argued that this policy approach aims at enhancing social capital – broadly understood as the stock of trust, norms and networks among individuals – in order to improve the social and economic situation of rural inhabitants, particularly of less advantaged, marginalised groups (Shucksmith, 2000; Farrell and Thirion, 2005). In this way LEADER-type policies are seen to create ‘win-win situations’ for various stakeholders in rural society (Farrell and Thirion, 2005).

Despite this economic parlance, economists have paid relatively little attention to neo-endogenous development so far, in particular there have been few attempts to analyse it with the aid of economic theory. From the perspective of neo-classical (regional) growth theory, the social coordination problems emphasised by other social scientists are typically downplayed by the often implicit assumption of perfect markets for labour and capital. Instead, in the canonical model such as summarised in Solow (2000), regional growth is determined by technological conditions. By equalising initial differences in capital and labour endowments, regions converge to a long-term equilibrium growth path solely driven by external technological progress. There is little role for policy, except for lubricating the movement of factors. Vicious circles such as mentioned before are not a concern, as they are supposed to be an expression of efficient factor adjustment (Maier, 2001).

The contribution of this article is a formal model of rural development based on evolutionary game theory that aims at generating new insights for both academic camps. For the audience of rural social scientists, it presents a set of modelling tools that picks up many of the concepts raised in the debate on neo-endogenous rural development. This unifying framework is used here to clarify the relationship among these concepts and offers specific notions of what, for example, the autonomy of stakeholders, self-organised interaction, innovative behaviour, and collective action induced by extralocal intervention could mean. It does so by referring to a behavioural framework – evolutionary game theory – that should be attractive for social scientists critical of the strong rationality assumptions typically invoked by rational choice theorists.

For the economist, the paper uses familiar economic language to shed light on rural development obstacles that typically escape the notice of traditional analysis. Based on the idea that coordination costs among agents are higher in rural than in urban areas plus the behavioural assumption of evolutionary learning without perfect foresight, a number of (from the neo-classical perspective) surprising insights are generated. In an environment of decentralised interaction, there may be self-reinforcing processes of either growth or decline that are contingent on the regional history. Depending on these processes there may emerge a global mosaic of coexisting prosperous and deserted rural regions, and Pareto-inferior outcomes may persist for a long time.

In a second step, I place particular emphasis on the role of an external policy authority and the circumstances under which it could help rural regions to reverse this rural race to the bottom. Given the evolutionary narrative of rural development implied by the model, government can set up a mediating platform (a ‘governance mechanism’) that allows agents with imperfect foresight to deliberate alternative development routes. Agents may thus stem the tide of rural decline by playing the rural coordination game in a different way. The main insight here is that policy is likely to be successful only if regional conditions are favourable in the first place. However, if they are, specifically targeted and relatively small expenditures may suffice. But they should be paid long enough to overcome the hardship of transition.

The evolutionary game depicts the simultaneous outmigration and investment inactivity observed in many rural regions. It is based on a one-shot asymmetric coordination game and models the interaction of two subpopulations (the Mobile and the Immobile), each with two strategies (stay/move and invest/abstain), which are paired once per period. Strategies are periodically updated based on successful outcomes of the previous period. Idiosyncratic deviations from best-response are possible, thus introducing the possibility of innovation. There are two equilibria: ‘Decline’ resulting from move/abstain, and ‘prosperity’ resulting from stay/invest, that is the successful realisation of an endogenous project. The former equilibrium is Pareto-inferior to the latter.

While public investment in a mediating platform, for example as in the form of LEADER funding, may reduce rural coordination costs, improvement does not come about automatically. It is rather modelled by a secondary collective action game nested in the evolutionary game of migration and business creation. Collective action is regarded as a self-reinforcing process once a critical participation rate is reached. The determining factors of a successful regime change from decline to prosperity are the individual propensity to participate, the level of financial support through policy, and the payoff to the endogenous project vs. the agents’ reservation wage.

The model proposed here is related to an emerging economic literature that is critical with neo-classical growth theory. It shares the idea of increasing regional economies of scale and positive agglomeration externalities with the ‘new economic geography’ (Krugman, 1991; Fujita and Thisse, 2002). However, different from the latter, positive agglomeration effects do not result from mutually reinforcing demand and income effects from saved transport costs, but from cooperative interaction of local agents that spreads among a region by learning processes. Such topics are also investigated in the emerging field of ‘evolutionary economic geography’, which couples ideas from the new economic geography with evolutionary and institutional economics (Boschma and Martin, 2010). With the latter, a focus on entrepreneurial dynamics, path dependency and network effects is shared here. Even so, neither of these branches considers the role of local collective action in dynamic regional development in more detail, which is thus a particular hallmark of the present paper.

In the following I first explain the leading neo-endogenous policy instrument in the EU, LEADER, in more detail (section 2). I then present some motivating evidence what the decline and prosperity of rural regions mean in the real world (section 3). Section 4 presents the details of the proposed model. Section 5 addresses its possible policy implications and introduces the collective action mechanism induced by an external

policy stimulus. Section 6 contains a simulation analysis of the model and section 7 concludes.

2 Neo-endogenous rural development policies in the EU

LEADER is relatively well-known and has been implemented in all EU member states, I therefore take it as a prime example of a neo-endogenous development approach. However, note that there are other programmes at the national level which follow similar design principles, such as ‘Regionen Aktiv’ in Germany and ‘Proder’ in Spain (OECD, 2006: 91). LEADER abbreviates ‘Liaison Entre Actions de Développement de l’Économie Rurale’, meaning ‘Links between the rural economy and development actions’. According to European Commission (2006), there are seven principles governing this policy approach: (1) It focuses on *local development strategies that are area-based* and not primarily of a sectoral nature, (2) it follows a *bottom-up approach*, thus giving local stakeholders a voice and power of decision making, (3) it supports and requires the establishment of *local public-private partnership*, the so-called local action groups (LAGs), (4) it puts much emphasis on *facilitating innovation*, (5) activities need to be *integrated* in that they include different economic, social and environmental players, (6) there should be *networking* among different LAGs, and (7) this networking may be intensified to establish comprehensive *cooperation* among regions.

Moving away from the traditional production focus of the Common Agricultural Policy (CAP), LEADER is thus multi-sectoral, decentralised, participatory, and community-driven. Its LAGs are based on regional partnerships between governmental and private actors with the intent of creating local development strategies based on local capabilities. Established in 1991, LEADER went to three generations called LEADER I (1991-93), LEADER II (1994-1999), and LEADER+ (2000-06). After 2007, LEADER became ‘mainstreamed’ and currently represents the horizontal axis in the rural development pillar of the CAP. The European-wide number of LAGs increased from 217 in LEADER I to 893 in LEADER+ and stood at 1458 by the end of 2009, while funding was raised from 442 million EUR in LEADER I to 9.2 billion EUR in the current period 2007-13 (European Commission, 2006: 7; ENRD, 2011). However, the relative share in total rural development funding remained relatively small, representing six per cent of EU funding for rural development in 2007-2013 (European Commission, 2011: 267).

LEADER is available for funding two types of activities: on the one hand, it financially supports regions to run a LAG and to engage in regional management. On the other, it provides funding for specific projects implemented by the LAG, which under LEADER+ typically have focused on the valorisation of natural and cultural resources, the improvement of the quality of life, enhancing local value added, on knowledge and new technologies to improve rural competitiveness, and on networking activities (European Commission 2009). In order to qualify for funding, private and social stakeholders (associations) need to contribute at least 50 per cent of the partners to the LAG.

3 The rural race to the bottom and how it can be reversed - motivating evidence

The symptoms of what OECD (2006) identified as a vicious circle are visible for many European rural regions in regionally disaggregate statistics such as published by European Commission (2011) or OECD (2011). Examples of declining regions can be

found, for example, in Eastern Germany, Italy's Mezzogiorno, or several of the EU's New Member States. The dynamic processes that lead to such decline have also been traced in case studies. One prominent case is Western Pomerania in Eastern Germany, as recently studied by Schrader et al. (2004), Reichert-Schick (2008), and Laschewski et al. (2009). By the end of the 1990s, the eastern rural county (Landkreis) of this region, Uecker-Randow, displayed an official unemployment rate of 25 per cent and was among the regions with the lowest GDP per capita in Germany (Schrader et al., 2004). Mostly younger and qualified people (particularly women) left the area in search for better jobs, leading to an annual net migration rate of about -6 per cent. Reichert-Schick (2008) shows how these socio-demographic dynamics induced a successive dismantling of public infrastructure in individual communities, such as grocery stores, post offices, kindergartens and schools, raising the issue of complete abandonment of some villages. Despite the existence of a local construction sector, the regional investment level was very low and was mostly generated by public entities such as the local army base.

However, as OECD (2006) points out, there are examples where such dire straits could be overcome by neo-endogenous development initiatives of the sort described in the previous section. Even in Western Pomerania, bottom-up activities based on local partnerships recently contributed to reverse the downward trend. For example, in the village of Woggersin a regional development centre was established in a previously unused farm estate building. This centre has been supported by the German 'Regionen Aktiv' programme and now hosts regular farmers' and Christmas market events as well as a local tourism office. Also due to its proximity to the city of Neubrandenburg, the village gained in terms of in-migration of young and well-educated individuals and families (Laschewski et al., 2008).

A broad variety of 'success stories' from other European regions is described in the LEADER best practices publications of the European Commission (European Commission, 2007; 2009). One such region is Almenland in Styria, Austria. It is a good example of how local initiatives can induce private investments into local resources and thus the creation of jobs and income for the local population. In the early 1990s, the region was characterised by small-scale agriculture mostly based on alpine grazing, a declining tourism sector, and significant out-migration. Almost every second inhabitant commuted to work outside the region (Naturpark Almenland, 2008; European Commission, 2007). Supported by LEADER II and LEADER+ funding, these trends could be reversed by a regional development strategy that is supported by a network of local actors, including farmers, food processors, tourism associations and local communes. The core of this strategy was to create the label of 'Almo Genussregion' ('Almo culinary region'), which primarily involved the cooperation of local farmers and the local food processor Schirnhofner. The aim of this cooperation has been the marketing of high-quality oxen meat produced on mountain pastures. Schirnhofner succeeded in establishing a marketing chain consisting of local restaurants under the label of 'Almenlandwirt' as well as the Austrian supermarket chain Zielpunkt. Furthermore, Almenland was registered as a trademark and the Almenland Marketing agency was founded. This local company has been engaged in various types of marketing activities, such as raising consumer awareness in supermarkets and launching press releases in the media. These steps led to a broad movement for regional innovation and networking based on local resources, including recreational services and cultural events. According to the initiative's reports, the label 'Almo Genussregion' led

to supplementary investment by local stakeholders of several million euro. 70 animal-friendly cowsheds were set up and 150 additional rooms for visitors established. According to estimates, 250 jobs were secured or newly created and several new companies focusing on products and services related to Almenland emerged.

4 Modelling rural development as a dynamic coordination game

4.1 Preliminary considerations

A decentralised and diversified programme like LEADER poses a considerable challenge for theoretical analysis. At the outset, it is hence useful to formulate the desiderata for such an analysis. One aspect that deserves highlighting is recognised by the policymakers themselves: LEADER is a policy that suggests *how* to proceed, not *what* needs to be done (European Commission, 2006: 8). It therefore differs substantially from established agricultural or regional policy measures which focus on funding specific activities, such as investment in farm assets or infrastructure, or environmental services. The focus of LEADER-type policies is rather on organisational principles and governance. Required is thus a theory of organisation and interaction, not allocation, as is traditionally used in agricultural sector analysis.

Furthermore, the process of ‘rural development’ needs to be interpreted and specified. As I put emphasis on *endogenous* rural development, the interpretation should be in a way that stresses the action and interaction of local stakeholders. In addition, I request that the model is dynamic so that it allows the analysis of rural development over time. It should be consistent with the vicious circle outlined above, that is a self-reinforcing process of decline. If we assume that this process can potentially be overcome, an implication is that multiple equilibria are possible and declining and developing regions co-exist. Finally, there should be a pathway through which external stimulus or animation, that is the presence of LEADER-type policies, can affect the development dynamics of the model. This also requires a specification of how these policies work and how they affect the actions of stakeholders in the model.

In the following, I show how evolutionary game theory can be used to formulate a model of rural development that principally meets these requirements. In the model, ‘rural development’ is interpreted as the increasing realisation over time of gains from interaction by rural stakeholders. In a highly stylised coordination model, some basic features of migration behaviour, business creation, and (lacking) entrepreneurship of the rural population are captured. This model has two equilibria, of which one is Pareto-superior to the other. Evolutionary game theory allows to study the properties of the model by assuming it is played repeatedly over time. I suppose that learning and innovation by adopting successful strategies of peers are possible. The process accommodates two dynamically stable equilibria, which depict declining and prospering regions. Which equilibrium is reached depends on the initial situation of a region and thus exhibits a path dependency. LEADER-type policies are interpreted as financial programmes that induce collective action on the side of the local stakeholders to overcome Pareto-inferior interaction outcomes in a given region and period. These policies are assumed to potentially break the path dependency. Given these policies and the characteristics of a region, there is a likelihood that the rural race to the bottom can be turned into an upward growth trajectory for that region.

4.2 Migration and rural business creation: a simple coordination game

In order to sketch a very simple model of the rural development process, I assume the rural population can be separated into two groups, the *Mobile* and the *Immobile* rural residents. Representatives of these two groups are assumed to interact following the payoff schedule shown in Table 1. The key idea of the game is that there exists a potential development project that requires the presence of both Mobile and Immobile. If they coordinate on the realisation of this project, the Pareto-superior growth equilibrium is reached. However, specific rural conditions of business creation, such as lack of agglomeration benefits and high financing costs, make the coordination of the two a non-trivial task. If they fail to coordinate and Mobile leaves the rural area, the inferior decline equilibrium results. In a later step, an external policy is introduced that aims to support coordination on the superior equilibrium. I now explain the details of the model.

Table 1: The rural coordination game

	Immobile invests locally	Immobile does not invest
Mobile stays in rural area	y, y	w_r, w_r
Mobile moves to urban area	$w_u, 0$	w_u, w_r

Notes: It is assumed that $y > w_u > w_r > 0$. y is the (equal) net payoff of an endogenous rural project carried out jointly by Immobile and Mobile, and w_u, w_r are the urban and rural net wage rates, respectively. Nash-equilibria are in boldface.

Source: Author.

Mobile has the option of leaving the rural for an urban area outside the model or stay in the rural area. Moving involves additional benefits (higher income) but also costs (such as higher housing costs, travel costs, and social or emotional costs of separation from family members). The moving option yields a net income of w_u , the urban wage, as shown in the bottom row of Table 1 (left entries in the payoff cells). Alternatively, Mobile may stay, in which case the payoff depends on the behaviour of Immobile.

Immobile residents by assumption cannot move, because they made irreversible investments in the past, they have little chances or interest in the urban job market due to rural-specific qualifications (such as farmers), or because their demographic situation does not permit this (because of dependent family members). As a default, Immobile pursue a low-paying activity with a payoff of w_r , the rural reservation wage (right entries in right column of Table 1). Immobile can nevertheless invest in a local project. If successful, this investment implies the move from a low to a high payoff activity for Immobile.

If Immobile invests and Mobile stays, both earn y , the payoff of the project which, for the sake of simplicity, is assumed to be of equal size for both (top left entry in Table 1). Furthermore, it is assumed that $y > w_u > w_r > 0$. If Immobile does not invest and Mobile stays nevertheless, both earn w_r (top right entry). If Mobile moves although Immobile invests, Immobile gets nothing (bottom left entry) and the project fails. Mobile's and Immobile's actions are thus strategic complements. If Mobile stays,

Immobile's potential investment return rise. If Immobile invests, Mobile's potential payoff from not moving rises also.

Using the solution concepts of classical, non-cooperative game theory (Dixit and Skeath, 2004: 86-90), this game has two Nash-equilibria in pure strategies, as indicated by bold letters: (abstain, move) and (invest, stay). However, (invest, stay) or what could be called the 'prosperity' equilibrium is Pareto superior to (abstain, move), an equilibrium of 'decline', and also to the two non-equilibrium outcomes. It may thus be taken as depicting a metaphor of the up- or downward spiral experienced in many rural regions of the EU. Note that the payoff to Mobile from moving is the same irrespective of Immobile's choice, and the same holds for abstaining Immobile irrespective of Mobile. There is no positive incentive to reach the 'decline' equilibrium if the other player is not going for 'prosperity'.

The logic of the model thus rests on the following premises: (1) The Mobile cannot realise the project without the involvement of the Immobile, (2) the Immobile cannot realise it without the Mobile, (3) bringing the two together is a nontrivial undertaking, and (4) an external stimulus has the potential to solve this coordination problem that the players alone cannot overcome. I discuss these premises in turn to show how they illuminate a problem that is likely to be particularly relevant in a *rural* setting.

Mobile represents the younger group of residents which still has alternative career and educational options. If properly educated, she brings human capital and new ideas to a potential project. She may actually represent the agents of change who facilitate the adoption of technical progress emphasised in the neo-classical models of regional development. However, the rural project also requires financial capital as well as local and possibly tacit knowledge. This project may be a business idea, such as tourist development, or new ways of marketing agricultural products. Because of her younger age as well as conservative banking practices and higher borrowing transaction costs in rural areas, Mobile cannot borrow the financial capital necessary to realise the project.¹ Furthermore, she lacks the intimate knowledge of local business conditions that is required to make the project successful. This knowledge may entail cultural traditions that could be valorised, knowledge about local production conditions in agriculture or the access to immobile resources such as real estate or services that are essential for the project. Note how the examples provided in section 3 – such as investing in holiday businesses or quality meat production and marketing – combine human capital-intensive services with local knowledge of production potentials and resources.

Immobile, on the other hand, may be more creditworthy than Mobile, for example because he owns more tangible assets or is regarded as more experienced. Furthermore, he has the local tacit knowledge required to carry out the project, such as knowing supply channels of relevant services. But Immobile cannot realise the project alone because it requires a certain number of qualified employees (or partners). These contributors are not there if Mobile leaves, and this reflects the now widely recognised problems of out-migration and ageing in rural areas (OECD, 2006: 26).

¹ Rural start-up firms commonly are constrained to rely on the '3F' of funding sources: the founder, family and friends. Equity capital is typically not available and fixed transaction costs for small loans to rural entrepreneurs are high (OECD, 2006: 75).

But why can Mobile and Immobile not simply write a contract about the joint execution of the local project? After all, this would imply that capital (in whatever form) meets labour, factor incomes move up and gains from arbitrage would be realised much in the neo-classical spirit.

The key reason advanced in this paper is that coordination (or ‘transaction’) costs are inhibiting this mutually beneficial outcome, and that these costs are particularly high in rural areas. More specifically, the parties may not know about each other or face considerable uncertainty about the other party’s behaviour. The typical benefits from agglomeration are missing in rural areas, such as a critical mass of businesses and/or educational facilities in a concentrated geographical area, access to specialised finance and labour markets, and the positive externalities in terms of information flow and risk reduction induced by such clustering. Moreover, transport and IT infrastructure are still deficient in many European rural areas. While people typically know a lot about each other in a single village, this is much less so in a larger rural area (such as a county). For Mobile, deciding to stay therefore implies a bet on the future initiatives by Immobile which are uncertain and whose promises cannot be enforced. Similarly, investing Immobile has to count on the presence of Mobile, who may turn out fugitive.²

While this description will sound familiar to the rural development practitioner, a game theorist will counter that the coordination problem presented in Table 1 should be easy to solve with a little ‘cheap talk’ among the parties. Following the classical set of assumptions, all agents know everything about the payoff matrix, including the payoffs *not* reached in actual play. Sending out a few signals about the preferred strategies of each of the players should suffice to realise the jointly desired outcome. Within the classical logic, this argument has some truth in it and therefore raises an important modelling issue. Note that the argument chiefly rests on the full information and strong rationality assumptions inherent to conventional game theory. Many social scientists dispute that these assumptions match the behavioural patterns observed among real world actors and feel uneasy with them. In the following, rather than trying to make the model more realistic within the classical framework (e.g. by introducing uncertainty or information asymmetry into a game of still fully rational players), I pursue the route of evolutionary game theory to enhance its plausibility. I first shift the behavioural assumptions to the other extreme, where agents have very limited oversight and learn from simple trial and error. In a later step, forward looking behaviour and reasoning about a possible alternative state of play are reintroduced, so that a ‘middle’ level of cognitive capacities is assumed. One advantage of the evolutionary approach is that it allows modelling in ‘real time’, by explicitly introducing dynamics to the rural development problem.

4.3 Making the model evolutionary

The skeleton interaction problem outlined in the previous section shall now be used as a basis for a dynamic model of endogenous rural development. A hallmark of evolutionary game theory is that it applies insights taken from evolutionary biology to the analysis of dynamic economic systems. The key biological mechanism adapted in evolutionary game theory is the dynamic *selection process* which changes the mix of

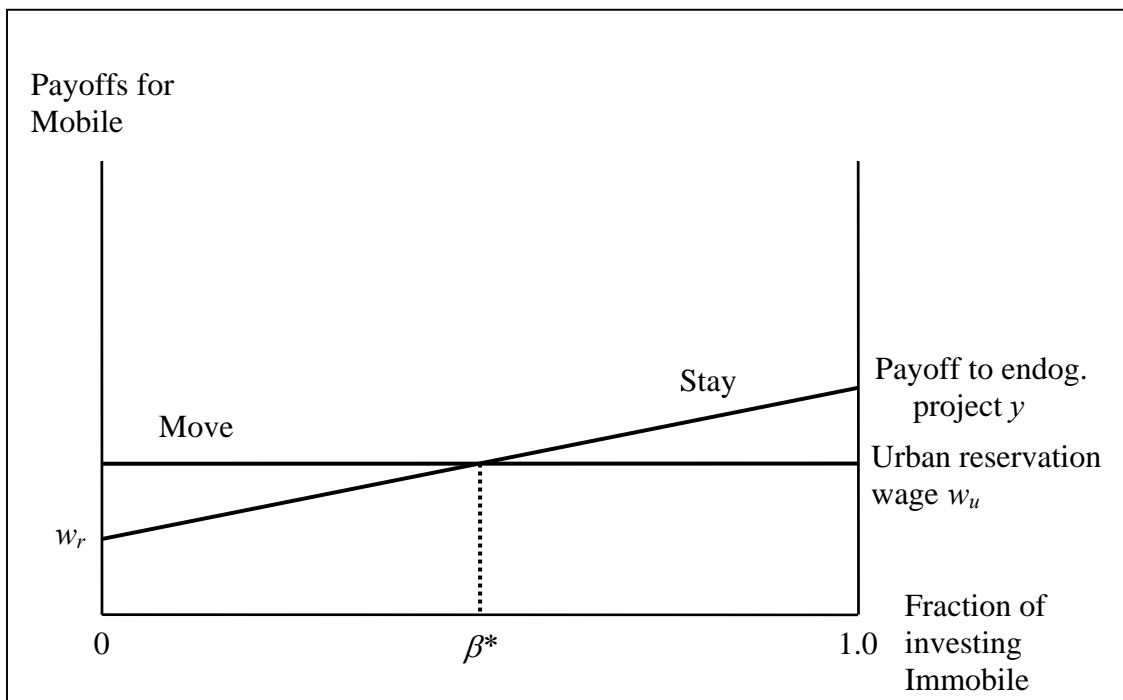
² Even signed labour or apprenticeship contracts are hard to enforce by rural companies should their young staff members decide to leave the area.

phenotypes with different degrees of fitness in heterogeneous populations (see Dixit and Skeath, 2004: 425-463, and Bowles, 2004: 56-92, for introductions, and Weibull, 1995, for a formal treatment of the subject). In the evolutionary game, the decision makers of the classical game are modelled as populations which interact in real time and which each include as many phenotypes as there are available strategies. The strong rationality assumptions used in classical game theory are replaced by simple adaptive behaviour. Individual strategies are interpreted as given phenotypes within a population. Their reproductive fitness is measured by the payoffs generated in the interaction with phenotypes present in other populations. The selection process is based on a rule that governs the periodically updated replication of strategies (the replicator dynamic). The structure of the population thus changes constantly over time unless it reaches an evolutionary stable equilibrium. Chance events or external stimuli may lead to mutations of the phenotypes, which may be more or less successful in invading the overall population. As fitter phenotypes dominate those which are less suited to the given environment, the latter die out. In economic games, mutations have the interpretation of innovative behaviour, while the replicator dynamic describing the selection mechanism formalises a process of imitation or social learning among peers in a given population.

The necessary ingredients of an evolutionary game are thus: (a) the definition of the interacting subpopulations, (b) the collection of phenotypes (strategies) in each subpopulation, (c) a matrix which defines the payoffs generated from interactions between phenotypes of different subpopulations, and (d) the selection rule defining the evolution of the relative shares of phenotypes in relation to their fitness (Dixit and Skeath 2004, 430). Given the dynamic proliferation, mutation, and decay of the phenotypes, the interesting questions addressed by such a model are which are its evolutionary stable equilibria (if there are any) and which processes determine how and why they are reached.

The following evolutionary model takes ingredients (a) to (c) from the game described in Table 1: the Mobile and the Immobile are the two populations of equal size with the phenotypes defined by the strategies move/stay and invest/abstain. The payoffs generated from interactions are given in the table. I thus work with a simple two-groups two-phenotypes evolutionary game. Note that the individual phenotypes have no freedom to choose their strategy at all, they are rather ‘born’ to play one strategy. In each period, they are randomly paired with a phenotype from the other subpopulation. Such a two-population coordination game has been a workhorse in the literature on evolutionary game theory. In the following, I present some intuition on its properties coupled with the specific application to rural development. A more technical analysis of the general model can be found in Weibull (1995: 163-228).

Given the payoff matrix in Table 1, the expected payoffs to the interactions depend on the relative frequency of the two phenotypes of the other population. They are shown for each population of the rural coordination game in Figure 1 and Figure 2.

Figure 1: Expected payoffs for Mobile

If we denote β as the fraction of investing Immobile on the horizontal axis, Figure 1 shows the expected payoffs for Mobile from each of the two available strategies (move/stay) on the vertical axis. The lines are drawn for arbitrary values of the exogenous variables that satisfy $y > w_u > w_r > 0$. The expected benefit for the staying Mobile, B_{ms} , is defined as

$$B_{ms} = w_r + \beta(y - w_r), \quad (1)$$

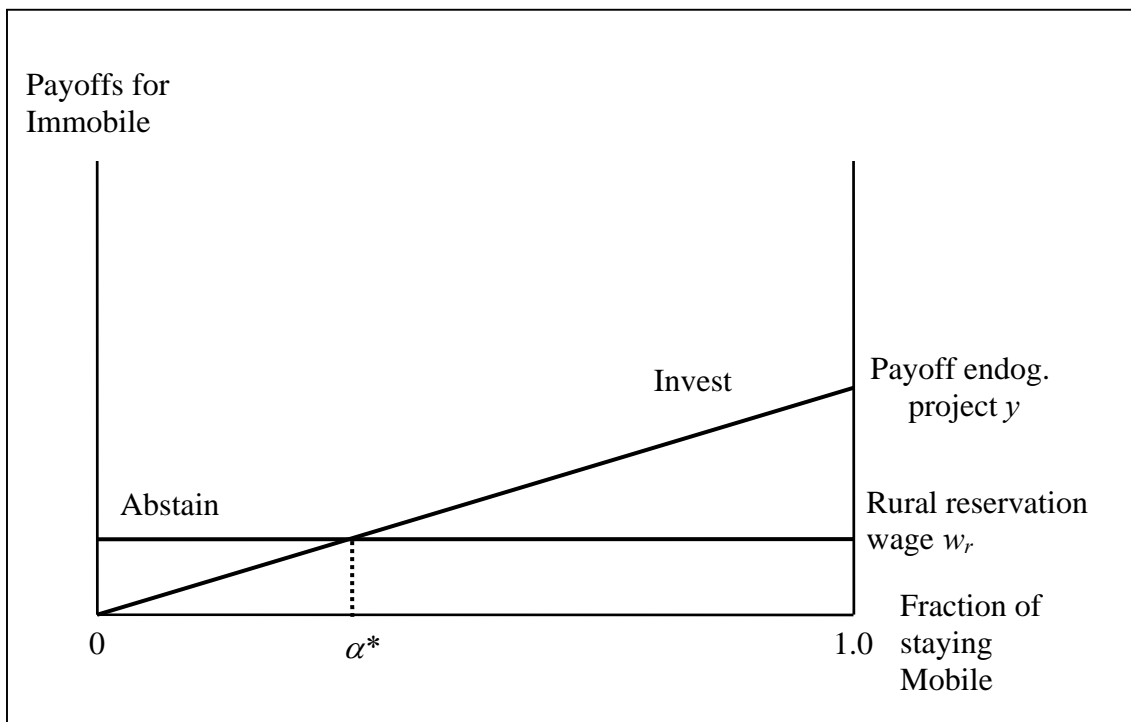
and thus increases in the fraction of investing Immobiles. The expected benefit for the moving Mobile is the constant urban reservation wage,

$$B_{mm} = w_u. \quad (2)$$

It is hence possible to calculate a critical fraction of investing Immobile, β^* , that is necessary to make 'stay' the best response for Mobile. This fraction is defined by $B_{ms} = B_{mm}$, which can be solved for

$$\beta^* = \frac{w_u - w_r}{y - w_r}. \quad (3)$$

If less than β^* Immobile invest, the Mobile will choose to move.

Figure 2: Expected payoffs for Immobile

Similarly, Figure 2 shows the payoffs for each of Immobile's strategies depending on the fraction of staying Mobile, α . The expected benefit for the investing Immobile, B_{ii} , is

$$B_{ii} = \alpha y. \quad (4)$$

The benefit for the abstaining Immobile is

$$B_{ia} = w_r. \quad (5)$$

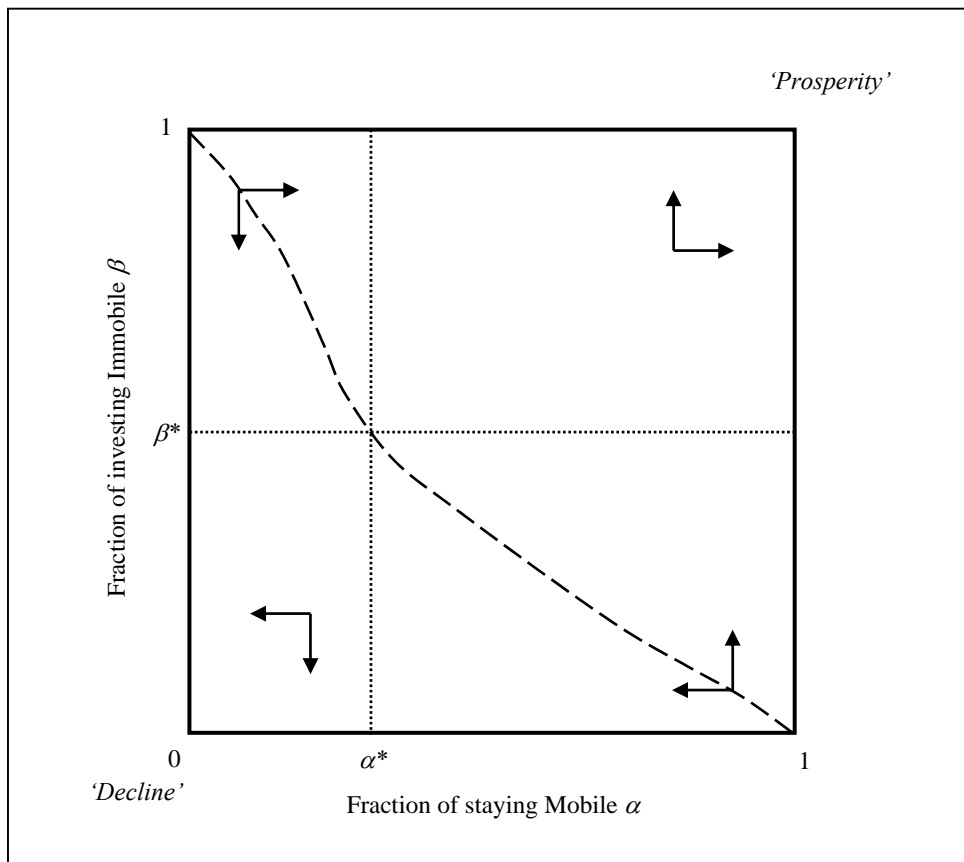
The critical fraction of staying Mobile that makes 'invest' the preferred option for Immobile is given by

$$\alpha^* = \frac{w_r}{y}. \quad (6)$$

The selection dynamic of the model is based on the assumption that each period, a fraction ω of each subpopulation updates their actions. Both Mobile and Immobile can hence be innovative and change their previous behavioural habits. A main source of such change is to learn from the fortunes of others. Empirical research on business start-ups has repeatedly documented that birth rates of enterprises are particularly high in regions where other enterprises had been newly founded before, and where appropriate role models are available (Mueller, 2006). This learning potential thus introduces a first *mechanism to reduce the information uncertainty* responsible for the coordination problem described before. It is captured in the model by an updating process. Updating

means that the phenotypes, which are simply the bearers of one of the two strategies, can switch to the other strategy. Whether they do so is determined by the expected success of the two strategies in the previous period and hence the relative fractions of phenotypes in the other subpopulation. If the strategy not borne by the phenotype has on average been more successful in the previous period, it is adopted. Otherwise, no switch occurs. For example, a moving Mobile may switch to ‘stay’ if $B_{ms} > B_{mm}$ in the previous period. As a consequence, $\Delta\alpha$ and $\Delta\beta$ have the signs of $B_{ms} - B_{mm}$ and $B_{ii} - B_{ia}$, respectively. The assumption that $\omega < 1$ ensures that external shocks have a persistent impact as they are transmitted over many generations (Young, 1998).

Figure 3: State space in the evolutionary game



The state of the population at any time t is described by a distinct pair of $\{\alpha_t, \beta_t\}$. Given the replicator dynamic explained before, the dynamics of the population may be depicted as in Figure 3. The critical fractions determining the switch between strategies define what could be called ‘tipping frequencies’ (Bowles, 2004: 409), which in our case separate the state space into four regions as shown in the figure. In the southwest region of Figure 3, $\Delta\alpha$ and $\Delta\beta$ are negative, so that (move, abstain) are the most successful pairings of strategies. The population will thus move to $\{0,0\}$, as denoted by arrows. Analogously, in the northeast region, the population will evolve towards $\{1,1\}$. In the northwest and southeast regions, there is a set of $\{\alpha, \beta\}$ combinations where the selection forces toward the northeast and the southwest equilibrium just offset each other. These are denoted by the dashed line running from the northwest to the southeast

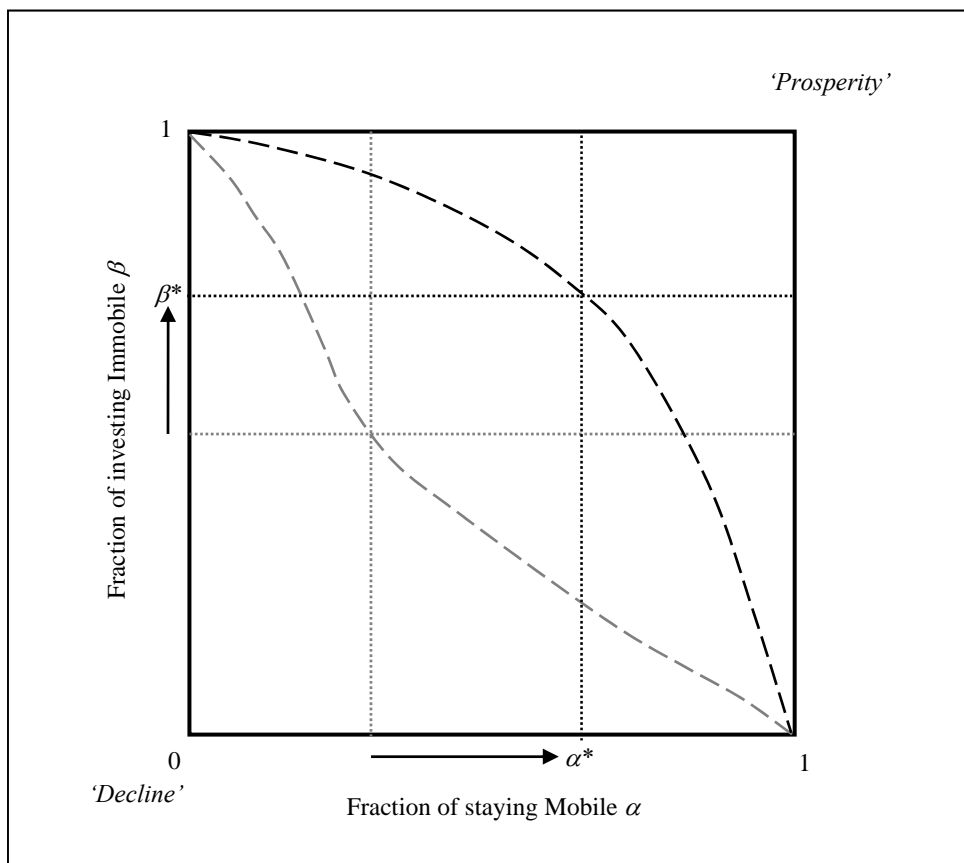
angle. States on this line move towards the $\{\alpha^*, \beta^*\}$ combination (Weibull, 1995: 183). The latter is a polymorphic saddle equilibrium that is unstable, as it can easily be left by perturbations to the northeast and southwest. However, $\{0,0\}$ and $\{1,1\}$ are stable equilibria in the sense of absorbing states, which means that they are never left once the population has reached either of these states. As only one phenotype of each subpopulation survives, the outcome is called monomorph. The dashed line thus separates the state space into two basins of attraction for the $\{0,0\}$ and $\{1,1\}$ equilibria. The sizes of these basins are determined by α^* and β^* . The dynamic process hence has two stable equilibria, a property that is called non-ergodic. Both equilibria, once established, cannot be successfully invaded by another phenotype. The prevailing phenotypes in the equilibria are both an evolutionary stable strategy (ESS). Which of the equilibria is reached depends on the initial $\{\alpha, \beta\}$, and thereby on the initial conditions of the system.

How does this model help to understand rural development processes? First, recall that the model interprets rural development as the successful coordination of two types of rural actors. The model supposes that the population of any given rural region can be divided into two subpopulations, the Mobile and the Immobile. It further assumes that there are gains to be had from productive interaction of staying Mobile and investing Immobile, but this equilibrium may or may not be reached. A fraction of both types of actors revises their behaviour on a regular basis, for example annually. In that year, the success of last year's interaction is studied and consequences for the own future behaviour are considered. Over time, either a productive equilibrium, denoted 'prosperity' in Figure 3, is reached, in which all Immobile invest and all Mobile stay. As a result, many 'projects' can be realised or businesses be run. Moving Mobile and abstaining Immobile die out. However, it is also possible that the inferior equilibrium is reached, denoted 'decline' in Figure 3, in which only moving Mobile and abstaining Immobile survive and everyone is worse off. Note how the evolutionary process gives meaning to the idea of endogenous development. As noted in the introduction, Ray (2006) stressed the bottom-up trajectory of this process, which characterises the decentralised, self-organised interaction of local stakeholders independent of external steering or planning. In the evolutionary model, this is interpreted as a process of 'spontaneous order' that is determined by countless interactions of individuals. Adaptive agents carrying simple behavioural rules reach, by trial and error, an outcome whose aggregate properties are not known to them beforehand and are thus not pursued intentionally.

It is instructive to show how the exogenous variables of the model affect the likelihood that a randomly chosen region ends up in one of the two opposing equilibria. To increase the likelihood of reaching the prosperity equilibrium, α^* and β^* as measures of persistence of 'decline' must be small and the (invest, stay) equilibrium must be easy to reach. This is the case the lower the urban reservation wage w_u and the higher the payoff to the joint project y . Regions that are disadvantaged in facing high urban wages in the target destinations of their Mobile and little potential for productive endogenous projects or businesses display a considerably smaller basin of attraction for $\{1,1\}$ and a reduced likelihood of reaching the 'prosperity' equilibrium (Figure 4).

The role of the rural reservation wage is ambiguous. A high w_r makes abstaining more attractive for the Immobile and thus increases α^* . At the same time it makes staying more attractive for the Mobile, hence decreasing β^* . In other words, while a low rural wage tends to drive away the Mobile, it also increases incentives for the Immobile to help themselves. To the extent that w_r characterises the economic status quo ante in a given rural region, its dual role provides an additional insight: In this model, the absolute level of rural income says nothing about the prospects for improvement. Due to the common reference wage for Mobile and Immobile, it is only the *differentials to the alternatives* (y and w_u) that matter. A region with a given rural wage level may display a large prosperity basin in one setting of y and w_u , and a small basin in another. Among two regions with the same w_r , one may have much bleaker prospects if there is strong competition with an urban centre or if no endogenous project ideas abound.³

Figure 4: The basin of attraction for prosperity shrinks in disadvantaged regions



The updating or learning process assumed so far is admittedly not very sophisticated and perhaps as unrealistic as the strong rationality assumption of classical game theory. However, making it less naïve by extending the memory or limiting the knowledge about the distribution of types in the other subpopulation does not fundamentally alter the outcomes of such models (Bowles, 2004: 408). A more important extension is to

³ Consider an alternative set-up in which w_r is only relevant as a reservation income for the Mobile, while the abstaining Immobile could realise, say, an alternative return on their capital r (on external financial markets). In such a model, regions with lower rural wages ex-ante would always face a smaller chance of improving their lot.

allow forward looking behaviour of the agents. This raises the question of what kind of information in addition to the past development of the system could be relevant for the actors. Given the rural development context of the model, the likely *future* behaviour of *other* agents is useful for current decisions. So far, I have argued that in the real world this information is costly and uncertain. It requires some extra collective arrangement to make it available, which is introduced in the next section.

5 Introducing politics to the model

Given the possibility of coordination failure and the emergence of Pareto-inferior equilibria over time, the question arises what society could do to avoid these undesirable outcomes. In the following, I highlight the fundamental trade-off between individual autonomy and centralised control inherent to this problem, which has in fact plagued generations of political philosophers but also played out in recent reform debates of EU agricultural policy. I argue that instruments like LEADER have the potential of going a middle way that avoids the disadvantages of top-down policy approaches traditionally dominating in rural and agricultural policy. The extension of the model described below attempts to shed light on at least some of the mechanisms that allow successful policy intervention from the outside. It assumes that an external government can establish a mediating platform which allows rural agents to lower their coordination costs. As will be seen, the success of this policy stimulus is far from automatic: the task of improving coordination in the migration-business game creates another collective action problem, namely to convince a sufficient fraction of peers that the coordination game should be played differently in the first place.

5.1 The trade-off between Spontaneous Order and Leviathan

The evolutionary model presented so far is consistent with a tradition in political philosophy descending from David Hume and Adam Smith to Friedrich von Hayek which stresses society's ability to self-organise. Proponents of this view argue that no central authority can have the relevant knowledge to successfully solve the coordination problems of society, only strongly decentralised systems can achieve this. Such systems, it is argued, also have advantages in terms of local experimentation with making the best out of a given, ongoing order of social institutions (see Sugden, 1993, for a general discussion). For those who assume that markets typically work well and that markets are the only institution necessary to coordinate exchange, this could be the end of the story. For adherents of such a 'laissez-faire' approach, no specific rural policy is required and a 'decline' equilibrium is accepted as a possibly regrettable but unavoidable outcome for the affected rural citizens.

But note that the 'prosperity' option could be available for those agents maintaining a 'decline' equilibrium. As reaching it requires a collective effort, it has the nature of a public good, and solving the information and risk problems involved in the coordination problem makes the help of an additional collective arrangement desirable. Indeed, with regard to normative questions of institutional change, the previous 'spontaneous order' tradition is contrasting with a tradition of 'institutions by design', according to which social rules are best engineered centrally, for example by the state (Bowles, 2004: 58, 475; Hargreaves Heap and Varoufakis, 2004: 207). This external authority may be able to imagine better rules as an outcome of deliberate reasoning and impose them on actors. Adherents to this view like Thomas Hobbes in his classical work 'Leviathan'

argued that coordination should be achieved by constraining the choices of individuals. They saw the strong state in a favourable position to enforce the relevant rules.

Given the relative simplicity of the coordination problem and our implementation so far, those actors playing (abstain, move) will clearly agree if an external authority enforced them to play (invest, stay). But although the model illustrates how both parties have a common interest in 'better' rules to play their game (Petrick and Pies, 2007), how exactly these rules should look like is a most difficult question in the real world. My concern here is that the naïve imposition of an omnipotent government authority misses the point of this complexity and some more modelling work is required to at least outline the subtle mechanisms of neo-endogenous rural development.

After all, programmes like LEADER also emerged because there was a perceived dissatisfaction with highly centralised agricultural policy programmes whose main objective was to channel subsidies into the farming sector. LEADER was thus a key element in the paradigm change towards a European policy that considers rural rather than agricultural interests (Ray, 2000; Petrick, 2008). Bearing in mind the calls for a more democratic and participatory policy that takes into account local resources and capabilities, a top-down policy package administered by a central authority cannot be the answer for declining rural regions. Such an approach is unlikely to have a superior solution to the local information and uncertainty problems causing the coordination failure in the first place.

The question is thus how the race to the bottom can be overcome under the condition that rural people are the best engineers and judges of their own fate. The answer our model gives is that this is possible only if both groups of actors intentionally play the rural coordination game in a different way, i.e. by collectively deciding to change the mode of play. Given a 'decline'-equilibrium, nonbest responses by both groups are necessary to navigate into the basin of attraction of the 'prosperity' equilibrium (Naidu and Bowles, 2005).⁴

5.2 Externally stimulated collective action in the model

The model thus far presented therefore needs an additional element which I call a 'local governance mechanism'. The latter is simply a label for arrangements or organisations that help solving the primary coordination problem described in the previous section. Loosely following Bowles (2004: 426-431), the functioning of this mechanism is subject to an additional, secondary coordination problem, as it is assumed to require collective action by a critical fraction of players. By introducing this mechanism I also allow that individuals have the capacity to look forward and can imagine the benefits they may have from an alternative state of play. In particular, they obtain the capacity to imagine what payoff they could realise if they all played the game differently. This critical ability can be enhanced by an external policy stimulus. It is here where the 'neo'

⁴ Alternatively, it is conceivable that change occurs as a result of *chance* events, or stochastic idiosyncratic play. The idea is that in the process of updating, there may be a positive probability that each individual may switch for idiosyncratic reasons. This may be due to experimentation, error, or another reason not captured by the model. The study of such processes is the domain of stochastic evolutionary game theory (Young, 1998). Its major problem is that, similar to biological evolution, the probability of change is very low and is thus likely only in the very long run. Furthermore, it is completely arbitrary, unless the emergence of idiosyncratic mutations is specified in more detail. We will therefore not consider this pathway further here.

of the neo-endogenous approach is introduced, in the form of stylised LEADER-type interventions.

In the real world, the ‘local governance mechanism’ may represent the following types of actions: Meetings of rural stakeholders where alternative development routes are deliberated, new information about innovative rural business models, training and education of rural stakeholders, networking with other ‘best practice’ projects, investing in certain infrastructures to foster new business creation (such as establishing a business incubator), or setting up and staffing a local development agency (a ‘local action group’). These are the types of activities that are typically funded in the framework of LEADER projects, although they could certainly also take place without such funding. The key point here is that it is easier to carry them out with the help of external, tailor-made funding schemes. On the other hand, they may also fail even if they are supported financially from outside. To emphasise the role of policy, it is assumed in the sequel that the secondary game is only played if there is some minimal stimulus (transfer payment) from outside.

Suppose a rural region is about to founder in a ‘decline’-equilibrium as explained in the previous section. To leave this course, the moving Mobile need to switch to ‘stay’ and the abstaining Immobile have to invest. Successful collective action means that a fraction of actors above the critical values for ‘tipping’ (α^* or β^*) in at least one of both groups engage in nonbest play in a given period. In a metaphorical sense, one could say the rural players decide to ‘stem the tide’ of rural decline. I presume that the individual willingness to stem the tide is determined by the influence of the local governance mechanism captured by a ‘governance impact’ parameter δ , and the size of the gains to be had, $y - w_x$. The gains differ for both groups, so that $x \in \{u, r\}$. The latter implies that people are more inclined to engage in a joint undertaking if the potential benefit in terms of future revenue is bigger. The impact δ is dependent on a financial transfer payment T , so that $\delta = \delta(T)$ and $\delta' > 0$. T measures the injected funding from LEADER-type policies. It seems plausible to assume that the transfer has diminishing effects, so that $\delta'' < 0$. This also prevents that just any region can be lifted out of decline as long as sufficiently high transfers are paid.

In addition to the benefits I assume there are also costs from collectively stemming the tide which are supposed to be particularly high if few others in the group engage in this activity. These costs of non-conformism depend on the fraction of participants in collective action, θ , with $0 \leq \theta \leq 1$, and the costs of being a sole non-conformist, c , such that $(1 - \theta)c$ are the costs for participants and θc the costs for non-participants. This model implies there is a critical mass phenomenon in the sense that, because it is less costly to do what most peers do, either all will participate or nobody will.⁵ The collective action problem is thus modelled as a multiperson coordination game.

⁵ Even regions with successful LEADER projects suffer from a lack of engagement by the broad public. The collective action model may therefore be more realistically limited to apply to a fraction of the total population only, namely those who are ‘asked’ or ‘called’ to participate. This ‘call’ could originate from a regional authority such as a local leader or the (prospective) management of the local action group.

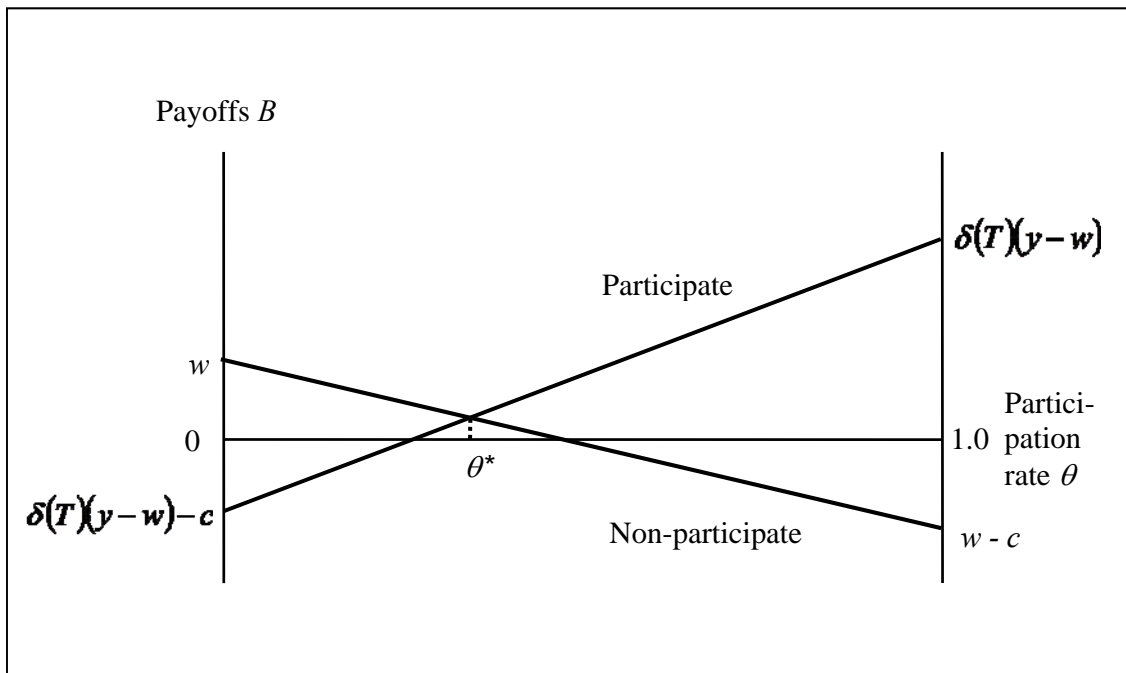
Whether or not collective action is carried out depends on the single-period net benefits from participation to the moving Mobile and the abstaining Immobile, B_{px} , and non-participation, B_{nx} , where

$$B_{px} = \delta(T)(y - w_x) - (1 - \theta)c \quad \text{and} \quad (7)$$

$$B_{nx} = w_x - \theta c, \quad (8)$$

with $x \in \{u, r\}$. These benefit functions are drawn in Figure 5 for a general w .

Figure 5: Payoffs in the collective action game for each subpopulation



It can be seen that there exists a critical value θ^* which equals the benefits from participation and non-participation. It indicates the participation rate above which participation becomes self-reinforcing. Successful collective action in each subpopulation will occur if more than θ^* individuals choose to participate:

$$\theta^* = \frac{1}{2} - \frac{\delta(T)(y-w) - w}{2c}. \quad (9)$$

Following Bowles (2004: 429), I solve this secondary coordination problem by assuming that each player weighs the benefits from participation and non-participation according to (7) and (8). That is, each player can imagine his/her personal benefit from choosing nonbest play mediated through the governance mechanism $\delta(T)$. The presence of the local governance mechanism thus 'opens the eyes' of all players towards their possible alternative options of play. To accurately allow each player to consider his/her benefit, an individual forecast of θ is required. The simplest assumption is that this takes the fixed value of 0.5, which means that every round half of the players are expected to participate in collective action. Furthermore, the game is a

one-shot game with pure strategies which is played independently in every round the governance mechanism is present.⁶

These assumptions allow the analyst to make a prediction about the success of the collective endeavour by using (9): If the second term on the right-hand side of (9) is positive, θ^* is smaller than one half and the individual expectation of $\theta = 0.5$ will induce the participation of all players. Note that it suffices to induce full participation in one of the two subpopulations in order to propel the population to the ‘prosperity’-equilibrium, as this will also change the best response of the other group.

Depending on the regional cultural setting or the local history of cooperation, other values of θ or structures of the collective action game may be assumed. In particular, one may want to make the current value of θ depending on collective action outcomes in previous rounds. In such cases, current cooperation is easier if successful cooperation happened in the past, and more difficult if past cooperation failed. While such path dependency can be observed in reality (Petrick and Gramzow, 2012), we leave its formalisation for future work.

According to the model outlined so far, collective action in a given region is more likely to succeed (θ^* is likely to be small) if (a) the impact of the governance mechanism is high, (b) the volume of available financial transfers is high, (c) the general inclination to cooperate expressed in the individual expectation of θ is high, (d) the difference between y and w is high, and (e) the level of w is low. However, the success of collective action is independent from the level of individual costs of non-conformity, as c does not influence the sign of the second term in (9). From (9), it can be seen that $\frac{\partial \theta^*}{\partial T} < 0$. The presence of LEADER funding increases δ and thus induces a parallel upward shift of the ‘participate’-line, making successful collective action more likely.

A further point to examine is how heterogeneous group size affects outcomes. Without giving up the logic of the interaction model in Table 1, it is conceivable that there are fewer Immobile than Mobile in the population (cf. Bowles, 2004: 426). Under such circumstances, one Immobile may interact with several Mobile per round, for example because the businesses or projects allow the presence of several dependent employees. In such a case, the Immobile get into a more favourable position to induce successful collective action. As each of them is paired with several Mobile, a smaller fraction of individual Immobiles playing ‘invest’ is required to induce the Mobile to switch to ‘stay’. If this case applies, the Immobile, as rural would-be entrepreneurs, are a particularly interesting target for LEADER-type policies. On the other hand, if there are more Immobile than Mobile, a case would emerge where certain Immobile have no interaction partner at all. While, in terms of payoffs, it is reasonable to assume that this will be identical to the case where Mobile move to the urban area, it does no longer allow to induce a regime change via nonbest play of the Mobile. One interpretation of this case is that the prospects for successful collective action in declining regions are even worse if the Mobile have left the region altogether so that no further interaction with the Immobile takes place. While it seems to be a plausible case, it is not included as a formal option in the model so far.

⁶ An alternative interpretation is that it is only played once for the entire period the governance mechanism is present.

Finally, note how the LEADER principles given in section 2 are reflected in the model. The importance of local strategies and the bottom-up approach (principles 1 and 2) are taken into account by the general structure of the model, which stresses that outcomes are the result of decentralised interaction of individuals. Innovation (principle 4) is carried by the notion of nonbest play in the process of updating individual strategies. The local partnership and the integrated nature of actions (principles 3 and 5) are captured by the secondary collective action game on setting up the local governance mechanism. Of course, the two highly stylised actors in the game-theoretic model present no full account of the stakeholders relevant in real-world LAGs, and also cannot be clearly identified with the three groups present in LEADER projects (private, social, and public). However, the model does provide the nucleus of a formal structure reflecting the multiple stages of individual and collective decision making that are relevant for LEADER-type policies. LEADER transfers coming from a government agency external to the model induce innovative nonbest play by the individual actors, so that the activities of the LAG produce the public good of superior coordination. Individual choices to play ‘stay’ and ‘invest’ despite its temporarily inferior payoff can be interpreted as expressions of local societal engagement. Explicit consideration of the networking principles of LEADER (6 and 7) is left for a future extension of the model. It may, for example, be added in the form of a tertiary game depicting this supraregional coordination activity.

With regard to the fundamental policy debate outlined in the beginning of this section, an interesting question is whether policy ‘intervention’ by instruments like LEADER is sufficiently modest to avoid the destruction of otherwise beneficial properties of decentralised coordination. If my interpretation of LEADER is correct, this policy could be regarded as a means to further the inherent coordination abilities of the relevant actors, by inducing them to engage in bottom-up collective action. This seems consistent with what Hayek (1976: 24) calls ‘immanent criticism’ (cf. Sugden, 1993), a process which attempts to reconcile the knowledge-processing capacity of spontaneous orders with external interventions that ‘gradually correct institutional ‘development traps’’ (Schubert, 2005: 121).

6 Simulating the model

In the following, I use the algebraic structure of the model as presented before in a numerical simulation analysis, calibrating it with the parameters given in Table 2. There are two types of regions successively simulated in the model, denoted advantaged and disadvantaged. An advantaged region is characterised by a set of parameter values for the payoff to the endogenous project as well as the urban and rural wage levels. These parameter values imply threshold fractions of staying Mobile and investing Immobile according to equations (3) and (6), also given in Table 2. Following the argument of Figure 4, lower levels for α^* and β^* make it more likely that a region coordinates on the ‘prosperity’ equilibrium, thus making it ‘advantaged’ (scenario A).

Table 2: Simulation scenarios

	Advantaged region	Disadvantaged region		
		<i>No policy</i>	<i>Successful policy</i>	<i>Unsuccessful policy</i>
	(A)	(B)	(C)	(D)
Payoff to endogenous project (y)	90	75	75	75
Net urban wage (w_u)	60	65	65	65
Net rural wage (w_r)	40	40	40	40
Critical fraction of staying Mobile (α^*)	0.44	0.53	0.53	0.53
Critical fraction of investing Immobile (β^*)	0.40	0.71	0.71	0.71
Policy effect $\delta(T)$	-	-	1.2	0.8
Period in which policy intervention starts	-	-	10	10

Notes: All scenarios were simulated for populations of 100 Mobile and 100 Immobile, and for 20 periods. In all scenarios, starting values for $\alpha = \beta = 0.5$, as well as $c = 1$, $\omega = 0.4$.

In contrast, in a disadvantaged region, the potential of the endogenous project is lower and the urban wage attracting the Mobile is higher than in the advantaged region. The values for α^* and β^* thus move up, making it more likely that the region coordinates on the ‘decline’ equilibrium (scenario B). In the disadvantaged region, two policy scenarios are simulated. Given the parameter values of Table 2 plus the criterion for successful collective action from eq. (9), a policy effect $\delta(T)$ of 1.2 is sufficient to make the success of this endeavour more likely than not (scenario C). The reverse is true for a value of 0.8 (scenario D). The latter essentially reproduces the outcome of scenario (B). These four scenarios were simulated for populations of 100 Mobile and 100 Immobile agents for a period of 20 rounds. Each population starts with an ‘undecided’ equal division into both relevant phenotypes, that is $\alpha = \beta = 0.5$. I further assume that $c = 1$ and $\omega = 0.4$. The latter ensures that adjustments are transmitted with sufficient delay to make the graphical analysis illuminating. In scenarios (C) and (D), policies were imposed from period 10 to the end.

Figure 6: Simulated model outcomes in three scenarios

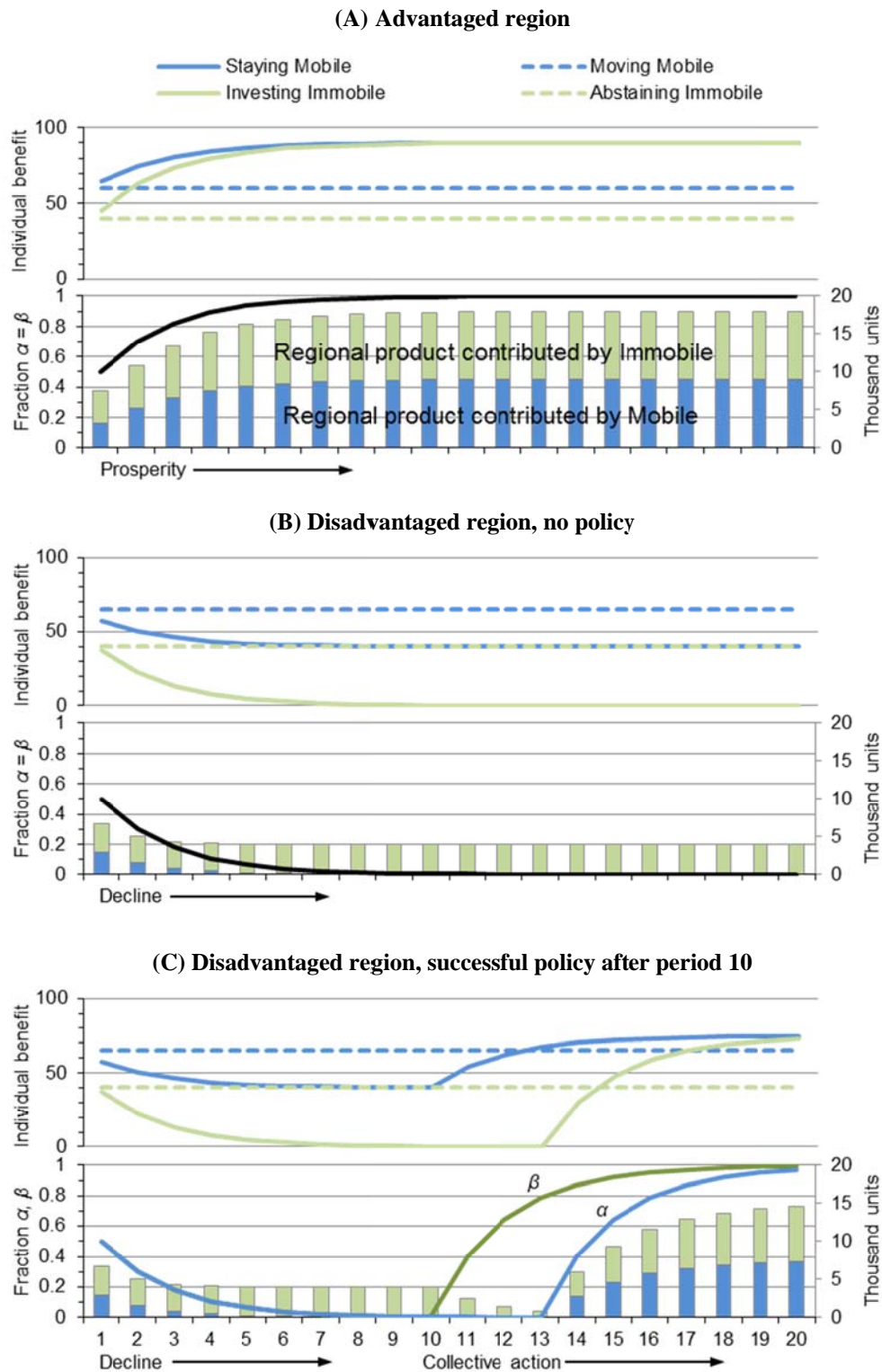


Figure 6 displays three sets of results for scenarios (A) to (C): the current payoffs to the individual phenotypes according to eqs. (1), (2), (4) and (5) in the upper chart of each scenario, the current fractions of staying Mobiles and investing Immobiles (α and β) for the beginning of each period measured on the left scale of the lower chart, and the

regional product contributed by each of the two populations measured on the right scale of each lower chart. The latter is obtained by first multiplying the number of staying Mobiles and the number of investing and abstaining Immobiles with their respective individual payoffs and then summing these up. The stacked bars of these cumulative benefits provide an indicator of the total regional product. By definition, the wages of the moving Mobiles are not part of the regional product.

Scenario (A) reflects a prospering region in which all Mobile agents decide to stay and engage, together with the investing Immobile, in an endogenous project yielding a payoff worth 90 units for each individual. The starting values of $\alpha = \beta = 0.5$ ensure that, right from the beginning, individual payoffs for contributing to the rural project are slightly above the reservation wages, drawn with broken lines in the upper chart. Periodic updating thus slowly augments the number of staying Mobile and investing Immobile. Both populations update with the same frequency and thus α and β grow by the same rate, displayed by a black line in the lower chart of scenario (A). This in turn increases the likelihood of pairing with a beneficial partner from the other population, and thus raises the expected payoff from staying and investing, respectively. The mutually reinforcing process continues up to the point where (approximately in period 10) no Mobile moves out of the region any more, and all Immobile invest. Given an aggregate number of 200 individuals, a total regional income of 18,000 units is realised in each of the remaining periods. This regional product is contributed in equal shares by each of the two populations.

Scenario (B) sets out with the same starting values for α and β , but the parameters given in Table 2 no longer ensure that staying and investing are the superior strategies under this population composition. These strategies are outperformed by the reservation wages, which is why more and more individuals switch to moving and abstaining, respectively. This in turn lowers the expected payoff for the remaining contributors to the endogenous project, so that in a process of decline a low-level equilibrium is gradually approached. In period 10, the last Mobile has turned to employment outside the region and the regional product is entirely composed of low-paid reservation activities performed by the Immobile.

In scenario (C), collective action triggered by an external policy stimulus reverses this ‘rural race to the bottom’, starting in period 10. The stimulus, by following the logic of eq. (9), convinces a sufficient fraction of the Immobile that additional gains worth 35 income units could be had if, together with the Mobile, the endogenous project was realised. All updating Immobile therefore turn to the investment strategy, leading to a rising β -line in the lower chart of scenario (C). Note how this comes at considerable cost as, initially, there is no payoff to this investment and the regional product further declines. However, as soon as staying becomes sufficiently attractive for the Mobile – the solid blue line crosses the dotted line in the upper chart – all updating Mobile turn to this strategy. This happens from period 14 onwards, when also the α -line goes up. As a result, the payoffs for the Immobile ascend also, exceeding the rural wage income from period 15 on. At this point, the process becomes self-reinforcing and approaches the high-level equilibrium in period 20. Given the parameter values for this scenario, the total regional product that can be achieved amounts to 15,000 units.

Two points in this last scenario seem to be noteworthy from a policy perspective. First, turning the tide leads to temporary economic hardship, as indicated by the shrinking

bars after collective action has been initiated. Second, it takes time (here: five periods) to make the process irreversible and self-sustaining. The political commitment to initiate collective action thus needs to be sufficiently enduring not to risk a pre-mature breakdown of the process. For such transitional periods, even external transfer payments to disadvantaged regions may be justified.

The results of scenario (D) are not displayed. In this scenario, the policy parameter $\delta(T)$ is slightly lowered, which may reflect a smaller commitment either by the local population in terms of willingness to engage in collective action or the policy makers in terms of funding. As a result, a critical fraction of investing Immobile cannot be mobilised and the collective action fails. The decline represented by scenario (B) is maintained.

7 Conclusions

Evaluated against the background of neo-classical growth theory, the model outlined in this article emphasises that the combination of factors to generate economic activity in rural areas is not automatic. In addition, it requires more than a change in production technology to stimulate growth. The present model rather highlights the need for coordination among different rural stakeholders – the young and mobile who bring new ideas but may easily leave to urban centres, and the older immobile who have better access to tacit knowledge and financial capital but depend on the presence of the mobile. As the agglomeration benefits typical to urban centres are missing, bringing both groups together in a rural setting is not trivial and implies that gains could be had from the involvement of an externally supported governance mechanism. Such a mechanism – broadly representing activities funded by LEADER-type measures – potentially helps rural people to stem the tide of rural decline and opens their eyes towards the alternative options of rural income generation they have. However, this only happens if a sufficient number of rural actors can be convinced that nonbest play is beneficial to them in the longer run.

By integrating concepts from other social sciences into the evolutionary game theoretic model, the social interaction represented here is much richer than typically assumed in standard growth theories. The rural coordination problem is particularly salient because agents' behaviour is restricted to adaptive learning in the first place. It requires an external trigger to engage them in collective action, and it is subject to group pressure implicit in the cost of non-conformist behaviour.

Different from the neo-classical convergence implication, the model predicts that the economic development of regions will lead to multiple equilibria. Furthermore, despite the Pareto superiority of the former, prospering and declining regions may coexist with no tendency to come closer to each other in economic terms. As a general result, a successful shift depends on the specific rural context. Regions that are disadvantaged in facing high urban wages in the target destinations of their migrants and little potential for productive endogenous projects or businesses are less likely to reach the superior equilibrium. The same applies if a governance mechanism has a poor impact and fails to re-coordinate the players. In this regard, rural outcomes cannot be planned or engineered from the outside, because initial conditions matter.

To the extent that it is taken as a plausible account of reality, the model yields a number of policy implications. First, 'small' interventions by the government may result in a

shift of equilibrium and thus have far-reaching consequences for economic outcomes. In real world cases, the financial transfers in the form of LEADER-type policies are typically very small compared to, say, the regional product. In this sense, neo-endogenous policies may be called ‘modern’ because they endorse an image of the slim state that reaches its goals with minimal outlays. The model also shows that external intervention may be possible and desirable without giving up the autonomy of local decision makers. After all, the role of policy is not to directly subsidise certain production activities or provide means for immediate consumption spending, as traditional social policies do. Policy rather stimulates agents to help themselves by playing their interaction more productively. Even so, the political commitment shall last sufficiently long to reach a self-supporting growth trajectory. Because the transition period towards the new equilibrium may entail economic hardship, temporary compensatory payments may also be justified.

While suggesting the nucleus of a new modelling approach to rural development, the model leaves numerous starting points for further extensions or modifications. For example, there is no account of what is happening outside the regions considered. There may actually be in-migration from urban or other rural areas, in response to the amenities a particular rural region provides. The policy stimulus is so far imposed on the region, while in reality there will be interesting political and social processes that lead to the attraction of LEADER-type funding (Marquardt et al., 2012) – in addition to the insight that a certain region is in decline. How exactly players are convinced to engage in nonbest responses to the ongoing game may be modelled more specifically. Empirical research has shown that the presence of local leader personalities plays a major role and that there exist complementarities between the governance mechanisms emphasised here and other, more conventional types of institutions, such as public infrastructure or markets (Petrick and Gramzow, 2012). Such promising extensions are left for future research.

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