ARGUMENTA
OECONOMICA
CRACOVIENSIA

No 15 • 2016
ISSN 1642-168X
AOC, 2016; 15: 43–56
DOI: 10.15678/AOC.2016.1503

Beata Ciałowicz

Andrzej Malawski

THE LOGIC OF IMITATIVE PROCESSES: IMITATION AS SECONDARY INNOVATION – AN AXIOMATIC SCHUMPETERIAN ANALYSIS

Abstract

This paper offers an axiomatic analysis of the imitative activity of producers in a Schumpeterian process of innovative change. It argues that structural change in the economy is generated by leaders of radical innovation, whose actions trigger the diffusion of innovations, and whose strategies and innovations can be copied by imitators. As a consequence, these imitators become second-order innovators operating in a production system that is deprived of primary innovators. The paper demonstrates that increases in the number and variety of second-order innovators can intensify innovative changes throughout the production system. Furthermore, this logic can be reconstructed by reference to the research programme on modelling Schumpeterian innovative evolution within the Arrow-Debreu dynamic general equilibrium theory.

Keywords: imitation, innovation, production system, axiomatic analysis, Schumpeterian approach.
JEL Classification: O31, O10, C6.

1. Introduction

The concept of imitation would appear to be ubiquitous in current evolutionary studies (Bessen & Maskin 2009, Glass 2010, Mukoyama 2003, Segestrom 1990, Shenkar 2010). Herrmann-Pillath (2013) states that at the

Beata Ciałowicz, Cracow University of Economics, Faculty of Finance and Law, Department of Mathematics, Rakowicka 27, 31-510 Kraków, Poland, e-mail: beata.cialowicz@uek.krakow.pl

Andrzej Malawski, Cracow University of Economics, Faculty of Finance and Law, Department of Mathematics, Poland

fundamental, phylogenetic level the role of imitation in the co-evolution of human brain size and human group size is crucial. Imitation, which is the basic form of human learning during ontogeny, is a uniquely human capacity. In contrast to apes, writes the German sinologist: "Human infants develop the capacity to imitate others' actions in a context-free way, that is, they become able to separate goals of actions from individual perspectives, and they can replicate intentions in their own actions" (2013, pp. 225–26). He also indicates the methodological significance of imitation which, if simply conceived as copying, allows us to model imitative copies by using techniques applied earlier to their originals.

Nelson and Winter (1982) claim that imitation is an important mechanism underlying the behaviour of firms. According to Safarzyńska and van den Bergh, it makes possible: "(…) savings on the costs of individual learning, experimentation or searching by exploiting information already acquired by others" (2010, p. 351). In this reading, copying can either mean replicating the most successful strategy or duplicating the strategy adopted by the majority.

By way of contrast, discussion of the Schumpeterian triad of invention, innovation and imitation has been dominated by the view that only its first two elements play a significant role in economic development. The part played by imitation has thus been somewhat neglected (Andersen 2009, Hanusch & Pyka 2006, 2007). Niosi (2012), however, suggests that the idea is ubiquitous in the evolutionary dynamics of industry. To explain its role in catching-up processes, for example, he discusses imitative innovation, which he defines as: "innovation that is only new to the countries and the firms that adopt the new product, process or organization, but is not necessarily new to the world, and is sometimes already known by consumers, in one form or another, in more backward countries" (Niosi 2012, p. 3). Niosi further argues that radical innovations causing structural changes on a global scale are rare; incremental innovations, on which imitation is based, are instead the norm.

Niosi (2012) formulates three general propositions. (1) Technological and organizational imitation is universal in economic development and has been theoretically underestimated. As Bolton (1993) has emphasized, Western pathos admires innovation and downplays imitation. The recent paper by Luo, Sun and Le Wung (2011) aimed at "emerging country copycats", illustrates the same trend. (2) Organizational imitation is an integral part of the diffusion process. (3) Imitation most often involves a certain degree of technological or organizational innovation, and there is a high degree of continuity linking imitation and incremental innovation. He concludes this part of his paper by stressing that: "imitative strategies, with a few exceptions (…) have been too often overlooked. They deserve a more thorough analysis, both at the micro and macro levels, in the debates about catching up, learning, and economic development" (Niosi 2012, p. 7).

Our aim in this paper is to add a fundamental analysis of the imitative activity of economic agents to the debate. We may conceive of this in more abstract terms by reference to innovators who cause structural and innovative change in the production sphere of economies by gaining a monopoly profit from innovative production and commercializing new goods, services or technologies. This initial state of affairs allows us to distinguish between firms that are laggards and firms that are leader-innovators. It should be borne in mind that the former are also heterogeneous agents, and that some of them are "preferred" as imitators in the copying of the production plans of leader-innovators. As a consequence, these imitators become secondary innovators operating in a production subsystem that is deprived of previous, primary innovators. This special selection mechanism for innovators that are once, twice or three times removed (extending potentially to infinity) from the primary innovators determines the diffusion of innovations, which is what guarantees their market success. Indeed, using a metric of innovation, we test the hypothesis that the more imitators there are, the more intensive are the innovative changes.

In the sense that they are reduced to, and operate in, a subsystem of a given economy, the paper seeks to study the logic of the imitative processes that define secondary innovators. This logic can be reconstructed by reference to the research programme on modelling Schumpeterian innovative evolution within the Arrow-Debreu dynamic general equilibrium theory (Malawski 1999, Malawski & Woerter 2006, Ciałowicz & Malawski 2011, *Innovative Economy* 2013), for which this framework would appear to provide an effective and convenient toolkit. Indeed, economic development in the Schumpeterian sense is modelled in this approach by innovative extension of the production system as a component of the Debreu economy, which is a setting that can serve as the base for studying imitative processes. The present study will therefore analyse the internal structure of the production system in a static setting and, specifically, explore the central hypothesis – that the more imitators there are, the more intensive are the innovative changes – axiomatically in the form of a theorem.

The paper examines a production system and an innovative extension of a production system in Section 2, before setting out an axiomatic analysis of a process of imitation in the given system in Section 3. The paper then proceeds to a study by theorems of the influence of imitation and imitators on the innovativeness of the production system. Conclusions are drawn in Section 5.

2. The Production System and Its Innovative Extension

The formal model of a production system takes the form of a two-range relational system (Debreu 1959, Malawski 1999, *Innovative Economy* 2013):

$$P = (B, \mathbb{R}^{\ell}; y, p, \eta, \pi),$$

where:

$B = \{b_1, \ldots, b_n\}$ is a finite set of the producers,

$\mathbb{R}^{\ell}$ is an ℓ-dimensional commodity-price space,

$y \subset B \times P(\mathbb{R}^{\ell})$ is a correspondence of production sets that to every producer $b \in B$ assigns a production set $y(b) = Y_b \subset \mathbb{R}^{\ell}$ that is a non--empty subset of the commodity space and represents the producer's feasible production technology,

$p \in \mathbb{R}^{\ell}$ is a price system,

$\eta \subset B \times P(\mathbb{R}^{\ell})$ is a correspondence of supply that to every producer $b \in B$ assigns a set $\eta(b)$ of the production plans maximizing his profit py_b in a price system p; that is to say: $\eta(b) := \eta_b(p) := \{y'_b \in Y_b\colon py'_b = \max_{y_b \in Y_b} py_b\}$,

$\pi\colon B \to \mathbb{R}$ is a maximum profit function that measures the maximum profit value in the set of plans $\eta(b)$, that is to say for $b \in B$: $\pi(b) := \pi_b(p) := \max_{y_b \in Y_b} py_b$.

In short, the production system is denoted: $P = (B, \mathbb{R}^{\ell}; Ch_P)$ where $Ch_P = (y, p, \eta, \pi)$ is a characteristic of system P.

In this system, each producer $b \in B$, operating in an ℓ-dimensional commodity-price space $\mathbb{R}^{\ell}$ tries to choose the production plans that will maximize profit in a given price system $p = (p_1, \ldots, p_{\ell}) \in \mathbb{R}^{\ell}$. The activities of a producer b which are governed by a set of production plans Y_b representing the producer's feasible production technology with respect to a correspondence of production sets y and by a feasible production plan, take the form $y_b = (y_{b1}, \ldots, y_{b\ell}) \in Y_b$. According to a correspondence of supply η and a maximum profit function π, which measures the maximum profit value in the set of plans $\eta(b)$ producers aim to select and execute the production plan that maximizes profits within the given price system.

Definition 2.1 (Ciałowicz & Malawski 2011, *Innovative Economy...* 2013)

Production system $P' = (B', \mathbb{R}^{\ell'}; y', p', \eta', \pi')$ can be called an innovative extension of system $P = (B, \mathbb{R}^{\ell}; y, p, \eta, \pi)$ (in short: $P \subset_i P'$), if

1) $\ell \leq \ell'$
2) $p = \mathrm{proj}_{\mathbb{R}^\ell}(p')$
3) $\exists b' \in B' \quad \forall b \in B$
   (3.1) $\mathrm{proj}_{\mathbb{R}^\ell}(Y'_{b'}) \not\subset Y_b$
   (3.2) $\mathrm{proj}_{\mathbb{R}^\ell}(\eta'_{b'}(p')) \not\subset \eta_b(p)$
   (3.3) $\pi_b(p) < \pi'_{b'}(p')$.

According to this definition, production system P' is an innovative extension of system P if at least one new product or commodity can appear in P' (condition 1). These new products, which can be interpreted as a better way of meeting the needs present earlier in system P, are introduced by new firms or by firms that already exist. In production system P' there is at least one producer b' whose technological abilities exceed those of all the producers acting in production system P (condition 3.1). It follows that the optimal, profit-maximizing production plans of producer cannot be reduced to the analogous plans being executed by the producers b' in production system P (condition 3.2). What is more, although the prices of "old" products do not change (condition 2), the maximum profit a fixed producer can make is greater than that of any of the producers in system P (condition 3.3).

It is evident that when $\ell < \ell'$, Definition 2.1 covers at least four cases of the five internal changes that Schumpeter (1934, p. 66) defines as development:

1) the introduction of a new good – condition 1,
2) the introduction of a new method of production – condition 3.1,
3) the opening of a new market – condition 1,
4) the reorganization of an industry – condition 3 as a whole.

Remark 2.1

1. A producer $b' \in B'$ that satisfies conditions 3.1, 3.2 and 3.3 is called an innovator. The set of all innovators is denoted by B'_{in}.

2. Some innovative production plans that satisfy condition 3.2 can be found among the new production plans of an innovator b' defined by condition 3.1. Innovator b' maximizes its profit, which is greater than that of any of the producers in system P.

3. The innovative production plans of innovator b' in production system P' are compared to respective characteristics of system P. At the same time,

the structure of the set of innovators is neglected. Of course, if there is an innovator $b' \in B'$ under conditions 1 and 2 then $P \subset_i P'$.

4. Conditions 1 and 2 are formally independent. If they obtain simultaneously, new commodities cannot appear as manna from heaven, that is, in complete isolation from the previous technological structure, which is modified by innovative production plans.

Formally: if $y'_{b'} = (y'_1, y'_2, \ldots, y'_{\ell'}) \in Y'_{b'}$ is an innovative plan condition 3.1 implies that $\mathrm{proj}_{\mathbb{R}^\ell}(y'_{b'}) \notin Y_b$ so $\forall\, y_b = (y_1, y_2, \ldots, y_\ell) \in Y_b$ $\exists\, k \in \{1, 2, \ldots, \ell\}$: $y'_k \neq y_k$. Hence innovative changes occur in the production of at least one commodity k. Moreover, for $\bar{k} \neq k$ $y'_{\bar{k}} = y_{\bar{k}}$.

5. The strict version of condition 1, $\ell < \ell'$, means that the radical innovations occur in the form of at least one completely new good or service, whereas $\ell = \ell'$ corresponds to incremental technological innovations.

The latter case would appear to be common in practice.

Proposition 2.1

If $P \subset_i P'$, $\ell = \ell'$, $y'_{b'}$ is an innovative production plan and there exists a unique (in short: $\exists!$) $k \in \{1, 2, \ldots, \ell\}$ such that $y'_k \neq y_k$ and $p_k > 0$ (this commodity is a rare good), then $y'_k > y_k$.

Proof

According to Remark 2.1 (4), condition 3.1 of Definition 2.1 means that $\exists\, y'_{b'} = (y'_1, y'_2, \ldots, y'_{\ell'}) \in Y'_{b'}$ $\forall\, y_b = (y_1, y_2, \ldots, y_\ell) \in Y_b$ $\exists!\, k \in \{1, 2, \ldots, \ell\}$: $y'_k \neq y_k$.

Moreover, condition 3.2 implies $y'_{b'} \in \eta'_{b'}(p')$, so $\pi'_{b'}(p') = p' \cdot y'_{b'} =$ $= p'_1 y'_1 + p'_2 y'_2 + \ldots + p'_{\ell'} y'_{\ell'}$.

If from condition 3.3 we have $\pi_b(p) < \pi'_{b'}(p')$, so $\forall\, y_b =$ $= (y_1, y_2, \ldots, y_\ell) \in Y_b$:

$$p \cdot y_b \leq \pi_b(p) < p \cdot y'_{b'} \Leftrightarrow p_1 y_1 + p_2 y_2 + \ldots + p_\ell y_\ell < p_1 y'_1 + p_2 y'_2 + \ldots + p_\ell y'_\ell$$

and consequently $p_k y_k < p_k y'_k$, then for $p_k > 0$: $y'_k > y_k$.

Remark 2.2

1. There are two different effects of innovative changes in technologies. Let $k \in \{1, 2, \ldots, \ell\}$. Then:

a) If commodity k, such that $y'_k \neq y_k$ is an output (a positive coordinate in a production plan) in an innovative production plan and other coordinates are fixed, then condition $y'_k > y_k$ means that the level of production of this commodity has increased.

b) If commodity k is an input, the condition $y'_k > y_k$ means that the technology used to produce this commodity is more efficient.

2. It is possible that for all the commodities that are different from commodity k $(\hat{k} \neq k)$ condition $p \cdot y_b \leq \pi_b(p) < p \cdot y'_{b'}$ implies that $p_{\hat{k}} y'_{\hat{k}} < p_{\hat{k}} y_{\hat{k}}$. Yet with the standard assumption that $p_{\hat{k}} > 0$, we have $y'_{\hat{k}} < y_{\hat{k}}$. This means that:

a) If commodity $\hat{k}$ is an output, its level of production decreases. This is because it is less innovative than commodity k (if commodity k is an output) or it is displaced from the market by any other commodity (if commodity k is an input).

b) If commodity $\hat{k}$ is an input in the production of another product, this technology is less efficient than before.

It is possible to generalize Proposition 2.1 to a case in which there are more commodities $k \in \{1, 2, \ldots, \ell\}$ in the given innovative production plan for which $y'_k \neq y_k$.

Proposition 2.2

If $P \subset_i P'$, $\ell = \ell'$, $y'_{b'}$ is an innovative production plan and for $k \in \{1, 2, \ldots, \ell\}$ such that $y'_k \neq y_k$ there is $p_k > 0$, then $y'_k > y_k$.

This proof is similar to the proof of Proposition 2.1.

3. Imitation as Secondary Innovation

Schumpeter (1934) defined technological change as having three main interrelated stages: invention (producing new ideas), innovation (implementing new ideas in products and processes) and the diffusion of innovation based on imitations (the spread of new technology among its potential uses). It is consistent with empirical observation that a wave of imitative activity follows a creative innovation. Schumpeter wrote: "(...) if anyone has in him all that pertains to success (...) then he (the innovator) can make a profit which remains in his pocket. But he has also triumphed for others, blazed the trail and created a model for them which they can copy. They can and will follow him, first individuals and then whole crowds" (1934, p. 133). This means that imitation allows firms to adopt techniques from other firms that they are not yet using in their production processes. So it is that, in spite of the extraordinary outpouring of innovative products and new technologies that we are witnessing today, imitation generates a far greater flow of novelty than innovation.

We need only look around us to see that imitation is not only more abundant than innovation, but actually a much more prevalent pathway to business growth and profits. In the real world, companies copy and succeed. IBM, Texas Instruments and Holiday Inns got into computers, transistors and motels as imitators. Just as the iPod was not the first digital-music player, the iPhone was not the first smartphone and the iPad not the first tablet. Apple imitated products but made them far more appealing. The pharmaceutical industry is split between inventors and imitators, while the multi-billion-dollar market for supermarket own-label products is based on copying well-known brands. In some cases this even extends to copying the packaging. The pace and intensity of legal imitation has quickened in the last twenty years. Rather than implying clones of goods or illegal counterfeits, global competition shows us that legal imitation can be a very positive force in a firm's development.

We can study innovative changes by investigating imitation in the demand and supply sides of an economy and by distinguishing a set of imitators among producers and consumers. In the context of the Schumpeterian approach, we will concentrate not on copying itself, but rather on imitators of innovative production plans. In this way we will study how imitation affects the supply side and can drive the diffusion of imitation. We begin by defining an imitative extension of a production system.

Let three production systems be given:

$$P = (B, \mathbb{R}^{\ell}; y, p, \eta, \pi), P' = (B', \mathbb{R}^{\ell'}; y', p', \eta', \pi'), P'' = (B'', \mathbb{R}^{\ell''}; y'', p'', \eta'', \pi''),$$

where $p'' = p', \ell \leq \ell' = \ell'', B = B' = B'', P \subset_i P'$ such that $B'_{in} \subset B'$ is a set of producer-innovators.

Definition 3.1

A production system P'' is called an imitative extension of a production system P' in short: $P' \subset_{ii} P''$) if there exist producers $b'_i \in B'_{in}$, $b'' \in B''$, $b'' \neq b'_i$ with production plans $y'_{b'_i} \in Y'_{b'_i}$, $y''_{b''} \in Y''_{b''}$ such that $y''_{b''} = y'_{b'_i}$ and $y'_{b'_i}$ is an innovative plan.

This definition is consistent with Niosi's concept of imitative innovation (2012).

Remark 3.1

1. Production plan $y''_{b''}$ is called an innovative imitation of plan $y'_{b'_i}$.
2. Producer b'' is called an imitator of producer b'_i.
3. If $y''_{b''}$ is an imitation of plan $y'_{b'_i}$ then $y''_{b''} \in Y''_{b''} \bigcap Y'_{b'_i} \neq \varnothing$.

Let $B''_{im} := \{b'' \in B'' : \exists\, b'_i \in B'_{in}\ b''$ is an imitator of the producer b'_i, $b'' \notin B'_{in}\}$ be a set of producer-imitators.

It is now easy to establish conditions to guarantee that production system P'', an imitative extension of P', is an innovative extension of production system P, $P \subset_i P''$. The following theorem is true.

Theorem 3.1

Let $P \subset_i P'$ and $P' \subset_{ii} P''$.

If there are producers $b' \in B'_{in} \subset B'$, $b'' \in B''$, with production plans $y'_{b'} \in Y'_{b'}$, $y''_{b''} \in Y''_{b''}$, such that:

1) $y'_{b'}$ is an innovative production plan (Definition 2.1)

2) if production plan $y''_{b''} \in \eta''_{b''}(p'')$ is an imitation of innovative plan $y'_{b'}$ (Definition 3.1), then $y''_{b''}$ is an innovative plan with respect to production systems P and $P \subset_i P''$.

Proof

Let $y'_{b'} \in Y'_{b'}$ be an innovative production plan. This means that for each $b \in B$ $y'_{b'} \in (\mathrm{proj}_{\mathbb{R}^\ell}(Y'_{b'}) \backslash Y_b)$, $y'_{b'} \in \eta'_{b'}(p')$ and $\pi_b(p) < \pi'_{b'}(p') = p'y'_{b'}$.

By Definition 3.1, if $y''_{b''}$ is an imitation of innovative plan $y'_{b'}$, then $y''_{b''} = y'_{b'}$. Moreover, for each $b \in B$ $y''_{b''} \in (\mathrm{proj}_{\mathbb{R}^\ell}(Y''_{b''}) \backslash Y_b)$, $y''_{b''} \in \eta'_{b''}(p')$ and $\pi_b(p) < \pi'_{b''}(p') = p''y''_{b''} = p'y'_{b'}$. This means that $y''_{b''}$ is an innovative plan with respect to system P and, following Remark 2.1 (3), $P \subset_i P''$.

The next theorem demonstrates the relationship between imitator and innovator.

Theorem 3.2

Let $P \subset_i P', P' \subset_{ii} P'', B = B' = B''$ and $b'_i \in B'_{in}$ be an innovator. If there exists $b'' \in B'' \backslash B'_{in}$ as an imitator of producer b'_i and $y''_{b''} \in \eta''_{b''}(p'')$ is an imitation of innovative plan $y'_{b'}$, then b'' is an innovator in production system P''.

Proof

Let $b'_i \in B'_i$ be an innovator, and $b'' \in B'' \backslash B'_i$ an imitator of producer b'_i. This means that there exists $y'_{b'} \in Y'_{b'}$ such that $y'_{b'}$ is an innovative plan, and there exists $y''_{b''} \in \eta''_{b''}(p'')$ such that $y''_{b''} = y'_{b'}$. Following theorem 3.1, $y''_{b''}$ is an innovative plan in system P'', so b'' is an innovator with respect to production system P.

Conclusion 3.1

$B''_{im} \subset B''_{in}$. This means that each imitator b'' in production system P'' for whom $y''_{b''} \in \eta''_{b''}(p'')$ is an imitation of innovative plan $y'_{b'}$ is an innovator in system P'' with respect to production system P. In other words, an imitator whose imitation production plan maximizes profits is a secondary innovator.

4. Imitation as a Driver of Innovativeness in Schumpeterian Perspective

Evaluating the innovativeness of an economy is one of the most important and difficult problems involved in analysing innovation processes. In this section we are concerned with comparing the innovativeness of two extensions of a production system. To do this we apply a metric of innovation (*Innovative Economy* 2013) that takes account of the qualitative changes in specific elements of the given model that are important for its innovativeness. This is a useful tool when studying the interaction of imitative and innovative activities in the process of innovative development. The aim of this section is to prove that imitations can intensify innovative changes in the production system and play a role as drivers of innovativeness.

Let a production system $P = (B,\ \mathbb{R}^{\ell};\ y,\ p, \eta, \pi)$ be given.

For this system interpreted as a basic model, let the set of all possible innovative extensions be denoted by $\boldsymbol{P^i}$:

$$\boldsymbol{P^i} = \{P^i\colon P \subset_i P^i\}.$$

Let two innovative extensions of the basic model: $P^i_1,\ P^i_2 \in \boldsymbol{P^i}$ be given such that:

$$P^i_1 = (B^1,\ \mathbb{R}^{\ell_1};\ y^1,\ p^1, \eta^1,\ \pi^1), P^i_2 = (B^2,\ \mathbb{R}^{\ell_2};\ y^2,\ p^2, \eta^2,\ \pi^2).$$

Definition 4.1

A mapping $\rho_i : (\boldsymbol{P^i} \cup \{P\}) \times (\boldsymbol{P^i} \cup \{P\}) \to \mathbb{R}$ such that:

$$\rho_i(P^i_1,\ P^i_2) :=$$

$$\begin{cases} 0 & \text{if} \quad P_1^i = P_2^i \\ |\ell_1 - \ell_2| & \text{if} \quad \ell_1 \neq \ell_2 \\ |card(B_{in}^1) - card(B_{in}^2)| & \text{if} \quad \ell_1 = \ell_2 \text{ and } card(B_{in}^1) \neq card(B_{in}^2) \\ |\pi^1(p^1) - \pi^2(p^2)| & \text{if} \quad \ell_1 = \ell_2,\ card(B_{in}^1) = card(B_{in}^2) \text{ and } \pi^1(p^1) \neq \pi^2(p^2), \end{cases}$$

where $\pi^1(p^1) = \sum_{b \in B^1} \pi_b^1(p^1) \neq \pi^2(p^2) = \sum_{b \in B^2} \pi_b^2(p^2)$,
is called the innovative metric.

This definition covers a broad spectrum of specific subcases of innovative changes. Radical product innovation occurs in the case of $\ell_1 \neq \ell_2$, which means that in the two innovative extensions given there are (1) different processes of creation and (2) that a good or service that is a new or improved version of a previous good or service has been introduced. Product innovation is ruled out in the case of $\ell_1 = \ell_2$ and $card(B_{in}^1) \neq card(B_{in}^2)$, but the sets of innovators are changing. We may note that the populations of innovators are the same in the last case. But because changes in new technologies are hidden behind different maximum profits, this condition can be interpreted as a process innovation.

The defined metric allows us to measure the difference between selected elements of two production systems so that the innovativeness of two innovative extensions of a given system can be measured in terms of their distance from the basic model.

Definition 4.2

A production system P_2^i is called:

1) an extension of system P that is at least as innovative as system P_1^i, in short: $P_1^i \trianglelefteq_i P_2^i$, iff $\rho_i(P_1^i, P) \leq \rho_i(P_2^i, P)$,

2) a more innovative extension of system P than system P_1^i, in short: $P_1^i \angle_i P_2^i$, iff $\rho_i(P_1^i, P) < \rho_i(P_2^i, P)$.

The metric defined above can now be used to describe the role of imitators in an innovative development. Indeed, it can be proved that innovative changes intensify when the number of imitators grows.

Theorem 4.1

Let:

1) $P_1'' = (B^1, \mathbb{R}^{\ell_1}; y^1, p^1, \eta^1, \pi^1)$, $P_2'' = (B^2, \mathbb{R}^{\ell_2}; y^2, p^2, \eta^2, \pi^2)$ be two different imitative extensions of production system $P' = (B', \mathbb{R}^{\ell'}; y', p', \eta', \pi')$, which is an innovative extension of production system $P = (B, \mathbb{R}^{\ell}; y, p, \eta, \pi)$ (in short: $P \subset_i P', P' \subset_{ii} P_1''$, $P' \subset_{ii} P_2''$),

2) $p' = p^1 = p^2$, $\ell = \ell' = \ell_1 = \ell_2$,
3) $P' \not\subset_i P''_1$ and $P' \not\subset_i P''_2$,
4) $card\,(B^1_{im}) < card\,(B^2_{im})$
then $P''_1 \angle_i P''_2$.

Proof

According to Theorem 3.2, we may notice that $P \subset_i P''_1$ and $P \subset_i P''_2$. There are of course no innovators in system P: $card(B_{in}) = 0$.

Moreover, taking into consideration Conclusion 3.1 and the assumptions $P' \not\subset_i P''_1$ and $P' \not\subset_i P''_2$ we have $B^1_{im} = B^1_{in}$ and $B^2_{im} = B^2_{in}$. Indeed, assumptions guarantee that $B^1_{im} \supset B^1_{in}$ and $B^2_{im} \supset B^2_{in}$ hold.

Thus, with the assumption that $\ell = \ell' = \ell_1 = \ell_2$, we have $\rho_i(P''_1, P) = = \left| card(B^1_{in}) - card(B_{in}) \right| = card(B^1_{in})$ and $\rho_i(P''_2, P) = \left| card(B^2_{in}) - card(B_{in}) \right| = = card(B^2_{in})$.

Hence, $card(B^1_{in}) = card(B^1_{im}) < card(B^2_{in}) = card(B^2_{im})$, so $P''_1 \angle_i P''_2$.

In general terms, the theorem states that innovative change becomes more intensive as the number of imitators increases.

5. Conclusions

This paper discusses the imitative activity of producers in a Schumpeterian process of structural change. Its chief aim is to show that imitators can be regarded as secondary innovators and that increases in the numbers of innovators intensify innovative changes throughout the production system. According to our approach, the innovations of leader-innovators are diffused when their production is imitated by other producers who can be regarded as secondary innovators.

In defining the intrinsic logic of the diffusion of innovations, the paper presents a new perspective on the important role played by imitators in innovative development. What is more, its results can be generalized to the whole Debreu economy where, for example, imitation can be analysed in a similar setting for a consumption system.

Bibliography

The Active Consumer: Novelty and Surprise in Consumer Choice (1998) ed. M. Bianchi. London–New York: Routledge.

Andersen, E. S. (2009) *Schumpeter's Evolutionary Economics*. London: Anthem Press.

Bessen, J. and Maskin, E. (2009) "Sequential Innovation, Patents, and Imitation". *Journal of Economics* 40 (4): 611–35, https://doi.org/10.1111/j.1756-2171.2009.00081.x.

Bolton, M. K. (1993) "Imitation versus Innovation. Lessons to be Learned from the Japanese". *Organizational Dynamics* 21 (3): 30–45, https://doi.org/10.1016/0090-2616(93)90069-d.

Ciałowicz, B. and Malawski, A. (2011) "The Role of Banks in the Schumpeterian Innovative Evolution – An Axiomatic Set-up" in A. Pyka, F. Derengowski, and M. da Graca (eds) *Catching Up, Spillovers and Innovation Networks in a Schumpeterian Perspective*. Heidelberg–Dordrecht–London–New York: Springer, pp. 31–58.

Ciałowicz, B. and Malawski, A. (2012) "The Role of Households in the Schumpeterian Innovative Evolution – An Axiomatic Set-up". Paper to the 14th International Schumpeter Society Conference, University of Queensland, Brisbane, Australia, 2–5 July.

Ciałowicz, B. and Malawski, A. (2013) "Demand Driven Schumpeterian Innovative Evolution" in A. Malawski (ed.) *Innovative Economy as the Object of Investigation in Theoretical Economics*. Kraków: Cracow University of Economics Press.

Debreu, G. (1959) *Theory of Value.* New York: Viley.

Glass, A. J. (2010) *Imitation as a Stepping Stone to Innovation.* College Station: Department of Economics, Texas A&M University.

Hanusch, H. and Pyka, A. (2006) "Principles of Neo-Schumpeterian Economics". *Cambridge Journal of Economics* 31 (2): 275–89, https://doi.org/10.1093/cje/bel018.

Herrmann-Pillath, C. (2013) *Foundations of Economic Evolution*. Cheltenham, UK–Northampton, MA: Edward Elgar.

Innovative Economy as the Object of Investigation in Theoretical Economics (2013) ed. A. Malawski. Kraków: Cracow University of Economics Press.

Luo, Y., Sun, J. and Le Wung, S. (2011) "Emerging Economy Copycats". *Academy of Management Perspectives* 25 (2): 37–56.

Malawski, A. (1999) *Metoda aksjomatyczna w ekonomii* [The axiomatic method in economics]. Wrocław: Ossolineum.

Malawski, A. and Woerter, M. (2006) "Diversity Structure of the Schumpeterian Evolution. An Axiomatic Approach". Arbeitspapiere / Working Papers of the Swiss Institute for Business Cycle Research No. 153, October. Zürich: KOF.

Mukoyama, T. (2003) "Innovation, Imitation, and Growth with Cumulative Technology". *Journal of Monetary Economics* 50 (2): 361–80, https://doi.org/10.1016/s0304-3932(03)00005-9.

Nelson, R. R. and Winter, S. (1982) *An Evolutionary Theory of Economic Change*. Cambridge, MA: Belknap Press of Harvard University Press.

Niosi, J. (2012) "Innovation and Development through Imitation (In Praise of Imitation)". Presented to the meeting of the International Schumpeter Society, Brisbane, Australia, 2–5 July.

Safarzyńska, K. and van den Bergh, J. C. J. M. (2010) "Evolutionary Models in Economics: A Survey of Methods and Building Blocks". *Journal of Evolutionary Economics* 20 (3): 329–73, https://doi.org/10.1007/s00191-009-0153-9.

Schumpeter, J. A. (1934) *The Theory of Economic Development*. Cambridge: Harvard University Press.

Segerstrom, P. S. (1990) *Innovation, Imitation and Economic Growth*. Econometrics and Economic Theory Paper No. 8818. East Lansing: Michigan State University.

Shenkar, O. (2010) "Defend Your Research: Imitation is More Valuable Than Innovation". *Harvard Business Review*, April: 28–29.

Abstract

Logika procesów imitacyjnych: imitacje jako wtórne innowacje – schumpeterowska analiza aksjomatyczna

W pracy zaproponowana została aksjomatyczna analiza działalności imitacyjnej producentów w schumpeterowskim procesie zmian innowacyjnych. Zgodnie z przedstawionym podejściem zmiany strukturalne w systemie ekonomicznym zostają zapoczątkowane przez działalność liderów w sferze produkcji, będących radykalnymi innowatorami, którzy inicjują proces dyfuzji innowacji, a ich strategie oraz wprowadzone innowacje mogą być powielane przez producentów będących imitatorami. W rezultacie imitatorzy ci stają się innowatorami „drugiego rzędu", dyskredytując jednocześnie innowatorów „pierwotnych". Zgodnie z tym głównym celem przedstawionej pracy jest wykazanie, że zwiększenie liczby imitatorów prowadzi do zintensyfikowania zmian innowacyjnych w całym systemie produkcji. Ponadto przedstawione ujęcie jest zgodne z programem badawczym dotyczącym modelowania schumpeterowskiej ewolucji innowacyjnej w aparacie pojęciowym ujętej dynamicznie teorii równowagi ogólnej Arrowa-Debreu.

Słowa kluczowe: imitacje, innowacje, system produkcji, analiza aksjomatyczna, ujęcie schumpeterowskie.