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Alternative food networks: growing niches or paradigm shift? Exploring the case of U.S. farmers' markets through a system dynamics approach[1]

Abstract: This article assesses the potential of Alternative Food Networks (AFNs) to successfully scale-up in order to be considered as an alternative paradigm to conventional, mass-distribution, retailing systems. To investigate this issue we consider the process of diffusion of AFNs as the typical process of adoption of a social innovation among potential adopters, which include both consumers and producers. By implementing a system dynamics model based on data relative to the development of farmers' markets (FMs) in the U.S., we find that the adoption/diffusion scheme depicts the historical evolution of such experiences across the Country. Our model underlines the role played by three main leverage points in determining the dynamics under investigation: the rate of opening of new farms, the rate of farm closings and the rate of urbanization. The baseline scenario, simulated without including policy intervention, shows that U.S. FMs reached their maximum diffusion over the past few years and the trend may turn negative in the forthcoming decades. To complete the analysis, we simulate 23 alternative scenarios for the development of US farmers' markets through the application of two hypothesis of policy intervention to the three leverage points. Only 10 scenarios out of 23 increased the number of farmers' markets during the period 2016-2044, and only three resulted both effective in increasing the number of FMs' and efficient in satisfying consumers' demand. No simulation indicates that U.S. FMs have the potential to radically scale-up and become a real alternative to conventional retailing systems. However, the best outcome has been obtained through the joint implementation of a strong control over concentration processes and a steady increase in the rate of farm openings. In conclusion we provide some policy-implications and few research indications for the further development of the debate about the future of U.S. farmers' markets.

Keywords: agri-food systems; alternative food networks; system dynamics; farmers' markets

[1] I would like to thank Dr. Davide Poggio, Dr. Michele Lancione, Andrea Saavedra and Francesco Menegat for their helpful advice and recommendations. All errors and omissions are my own.

I. INTRODUCTION

The last decade of the twentieth century sought the emergence of new discourses and practices relative to the rural-urban divide in westernized societies. Both agricultural and urban landscapes in their geographical, cultural and environmental acceptations, have been gradually reconsidered as complementary and interdependent sources of wellbeing for society at large (MEA 2005; Barton and Pretty 2010). The assumption about the functional divide between the city (producing wealth and consuming primary goods) and the countryside (producing primary goods and consuming wealth) has been increasingly recognized as a misreading of the complex interactions allowing the prosperity of societies (Scott *et al.* 2007). In reaction to such dichotomy, food systems have been identified as the nexus between rural and urban landscapes where the integrity of both people and ecosystems is at stake (Morgan 2015; Marsden and Sonnino 2012). By growing as a cultural, economic and political phenomenon, the original insights brought in by such perspective set the ground for the development of a new kind of relationship between the city and the countryside, directly involving both food consumers and producers (Parkins and Craig 2009). In reaction to the commodification of human nutrition entailed by the tendency of industrial societies to consider food as a convenience good, experiences of alternative food networks (AFNs) emerged as strategies to redefine food as a credence good where the relationship between producers and consumers allows the exchange of non-standardized products outside the conventional channels of mass distribution (DuPuis and Goodman 2005; Renting *et al.* 2003). Defined as a form of social innovation which is developed between producers and consumers, AFNs include: direct marketing, community supported agriculture programs, farmers' markets, community self-organized schemes, transition networks (Goodman *et al.* 2012). While several analyses provided evidence that AFNs can generate environmental, economic and social benefits (Pretty 2001; Brown and Miller 2008; Hughes *et al.* 2008; Coley *et al.* 2009; DeWeerdt 2009; Martinez 2010; Santini and Gomez y Paloma 2013), it is still debated in the literature whether such experiences will be able in the next future to scale-up or not (Sonnino and Marsden 2005). On this issue, the available literature follows two main theoretical frameworks: 1. A well developed literature adopting behavioural and economic approaches investigated the role played by both consumer's and producer's motivation towards participating in AFNs (Zepeda 2009; Zepeda and Li 2006; Bond *et al.* 2006); 2. A second approach, based on disciplines like critical geography, sociology and anthropology, examined the role played by political issues, struggles and motivations underlying the functioning and the expansion of AFNs as social and cultural movements (Goodman *et al.* 2012; Parkins and Craig 2009; Renting *et al.* 2003). Both streams of research provided relevant information about the structure of AFNs, shedding light on the opportunities and the barriers that may affect their development in the future. By integrating the literature available with an original perspective based on the interpretation of AFNs as systems of social innovation, this paper analyses their evolution in industrialized countries in order to assess whether such experiences can be considered as emerging paradigms able to challenge conventional mass-distribution systems or simply as growing green niches involving small fractions of producers and consumers (Smith 2006; 2007). As a case study, the analysis explores the growing role of local food markets in the U.S. (Hardesty 2008), by focusing on the case of farmers' markets (FMs). By implementing a system dynamics model, the study aims to provide further insights about the historical development and the prospects for the future expansion of AFNs in western countries, shedding light on the major barriers that might affect their evolution and the possible policy-options that could be effective in overcoming them. The article is organized as follows: section two introduces the theoretical framework adopted; section three presents the methods and the detailed description of the model developed; section four includes the analysis of the scenarios elaborated and section five discusses the results of the simulations in terms of policy implications; in the conclusions, the limitations of the approach here adopted are underlined and future research directions are suggested.

2. AFNs, SOCIAL INNOVATION AND THE DIFFUSION OF FMs IN THE U.S.

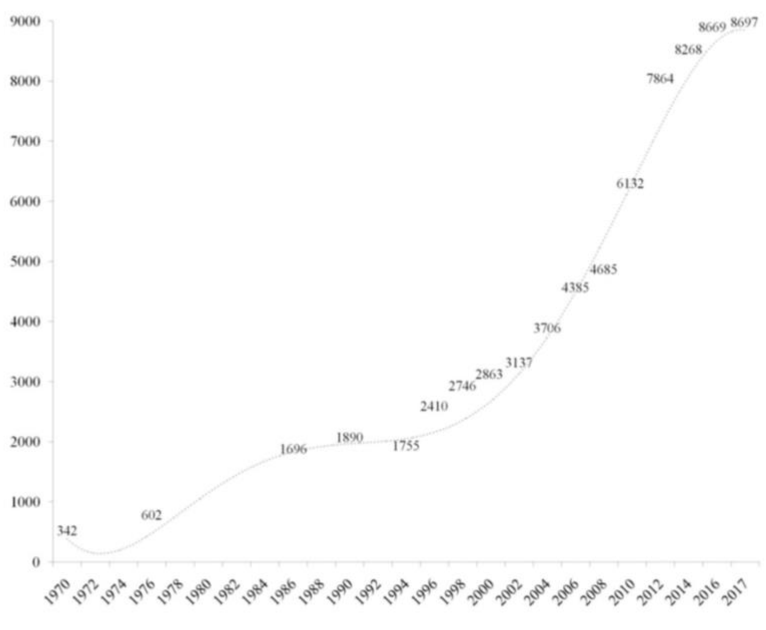
Following the classification proposed by Goodman *et al.* (2012), FMs can be considered as a first generation, market-oriented, scheme of AFN. Rather than being breakthrough innovations revolutionizing the functioning of agri-food systems, it is more appropriate to refer to the evolution of U.S. FMs as a renaissance leaded by an incremental process of social innovation (Hinrichs *et al.* 2004). Such definition refers to the introduction of "[..] *novel solution to a social problem* [..] [by which] *the value created accrues primarily to society rather than to private individuals*" (Phills *et al.* 2008: 36). According to the literature on AFNs, the recent development of FMs can be seen as a result of an innovative process oriented towards a twofold goal: (i) to provide answers to social concerns, such as environmental, socio-economic or public health issues (Goodman *et al.* 2012; Seyfang 2006; Hinrichs *et al.* 2004); and (ii) to allow the organization of new forms of business strategies, rules and social relationships to emerge and shape a new system of production and consumption (Holloway and Kneafsey 2004). When social innovations arise, they generally take place at the scale of niches embedded in the dominant socio-technical system (Smith, 2007). According to the scheme proposed by the new institutional economics theory (North 1991), the widespread adoption of both technical and social innovations is subject to the implementation of an institutional framework regulating the new form of production and/or consumption. AFNs are good examples of innovation niches that depend on and interact with the institutional, socio-economic and technical frameworks (Smith, 2006). Within this context, innovators –both producers and consumers– perpetuate the classical scheme of diffusion of innovations, where imitators follow pioneers until demand or supply result saturated (Rogers, 1962). As Heffernan (1982) and Nowak (1984) stated, the adoption/diffusion of innovative practices in agri-food systems can be better addressed by analyzing the aggregate economic, structural and institutional characteristics of the context rather than the personal motivations of farmers, who are normally subject to numerous constraints from the surrounding environment (Padel 2001).

2.1 FMs as forms of social innovation

For what pertains the case study considered in this paper, Brown (2002) notes how the first farmers-pioneers were pushed to re-discover the economic and the social relevance of direct marketing and local community engagement in response to the generalized crisis that affected the U.S. farming sector from the end of the 1970s'. The socio-economic and institutional conditions established during thirty years (1945-1975) of national policies oriented to increase specialization and consolidation of large businesses (Sexton 2013) compromised the resiliency of small farms, which gradually sought FMs as alternative channels to market their products while realizing higher margins. After a period of increasing, albeit informal, interest around FMs, in 1976 the U.S. Government approved the first law oriented to institutionalize the re-emerging social and economic practice that small-farm owners were undertaking in order to sustain their income (Brown 2002). Following the Farmer-to-Consumer Direct Marketing Act (PL 94-463), new and institutionalized FMs grew exponentially across the Country, reaching a peak in 2017 at 8,697 markets (Fig. 1).

Although data for the years prior to 1994 is partially missing (Brown 2001), the graph illustrates that AFNs, and, in particular FMs, cannot interpreted simply as fads determined by the diffusion of temporary consumption habits. On the contrary, these experiences are consolidated structures of the US farming landscape, able to grow and expand when the institutional framework results adequate. The US administration dedicated much attention to the promotion of FMs over the past decades, with several federal and sub-federal programs to improve and to communicate the range of such experiences. However, what emerges from the graph 1 is the fact that the diffusion of U.S. FMs seems to be following the typical S-shaped trend due to the exhaustion of the potential gains associated with the diffusion of innovations in mature markets (Rogers 1962).

FIGURE 1 • NUMBER OF FMS IN THE U.S. 1970-2017



Source: own elaboration based on USDA (2016) and Brown (2001).

As a report from the U.S. Department of Agriculture (USDA 2015) underlines, the growth pace of FMs has dramatically slowed down during the last years, and the reason could depend on both the demand or the supply side.

In the first case, demand for locally grown food would have reached a plateau. In this scenario, competition among farmers would increase dramatically, the less efficient

FMs would close, and the rate of opening of new FMs would decrease until stopping at a certain level.

The second hypothesis assumes that supply is stabilizing due to barriers in the process of involving more farmers in the organization of FMs, or given the scarcity of small farms located in proximity of urban areas. As the authors of the report argue, if farmers are located too far from their potential customers, their participation in AFNs would shift towards other forms of retailing systems (such as food hubs or institutional purchasing) that could allow them to better manage the high transaction costs of direct marketing (USDA 2015).

While the first hypothesis is often assumed to be the major driver responsible for the observed trend, there is still no evidence that the potential market for FMs has been saturated. By contrast, the proportion of farms for which FMs represent a viable marketing channel could be very low, because farming operations have to be, at the same time, small or medium-sized and have located in proximity of urban agglomerations that represent their primary catchment areas (Mack and Tong 2015). As Padel (2001) argues, early adopters correspond to particular regional categories of customers (divided by sex, gender, income level, education) and farmers (small-farms owners, educated, progressives). After the innovation is introduced, the niche can attract other categories of subjects, often animated by different goals then the ones of the pioneers. In the medium-term, such dynamics design a double S-shaped curve for both the two typologies of adopters: consumers and producers.

2.2 Drivers of the of the diffusion of FMs in the U.S.

During the past twenty years, many survey-based studies in different contexts across the U.S. investigated the attractiveness of FMs among households, underlying the relationship between local food consumption and social, demographic and economic characteristics of individuals (Zepeda 2009; Bond *et al.* 2006; Zepeda and Li 2006). By analyzing geographical data, Schupp (2015) studied the diffusion of FMs among neighborhoods of several cities in the US obtaining results similar to those of individual-based surveys. However, for the sake of this paper, it is necessary to adopt a nation-wide point of view in order to obtain an estimate of the main drivers determining the aggregate demand for FMs. Unfortunately, there are no studies exploring this dimension. To temporarily fill this gap, it is useful to assess what variables are more correlated with the diffusion of FMs across the US. By considering several demographic and economic characteristics of the 3,142 US counties, an

Ordinary Least Square regression (OLS) confirms that several components contribute more than others to the diffusion of FMs (Tab. 1).

TABLE 1 • FACTORS EXPLAINING THE NUMBER OF FMS IN U.S. COUNTIES: O.L.S. RESULTS

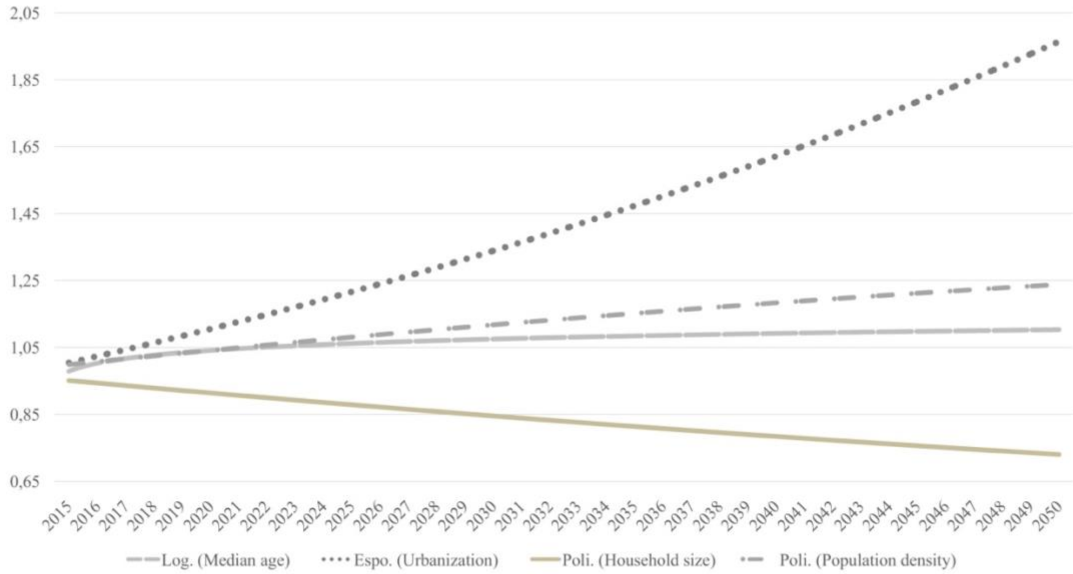
	Coefficient	Std. Error	t-ratio	p-value	
Constant	3.000180	1.411850	2.12500	0.033670	**
Population Size	0.000012	0.000001	9.32230	<0.00001	***
Average Age	0.024039	0.014620	1.64470	0.100130	
Number of Farms	0.000640	0.000170	3.67240	0.000240	***
Household Size	-1.594460	0.344100	-4.63370	<0.00001	***
Pop. Density	0.000417	0.000073	5.70780	<0.00001	***
Urbanization Rate	1.448100	0.369870	3.91520	0.000090	***

Mean dependent var.	2.358	S.D. dep. Var.	5.251
Sum squared resid.	27705.7	S.E. of regression	2.972
R-squared	0.68	Adjusted R-squared	0.679
F(6, 3136)	138.9	P-value(F)	1.80E-156
Log-likelihood	-7880	Akaike criterion	15774.1
Schwarz criterion	15816.4	Hannan-Quinn	15789.3

Source: own elaboration on USDA (2014) and United States Census Bureau (2010).

Except for the component "Average Age", whose p-value is too high, the other variables are strongly correlated with the diffusion of FMs. In particular, it is interesting to note that the average household size has a negative effect on the dependent variable (number of FMs), and the reason is, intuitively, that a greater number of small households consumes more than a lower quantity of larger ones. Urbanization, median age and population density are other factors influencing the distribution of FMs in a positive way, along with the population of the county. Assuming that population size will not change significantly during the next decades at the national level, the analysis can focus on the other components of the regression. By looking at the expected future trends of the variables correlated with the diffusion of FMs (Fig. 2), we can conclude that the aggregate demand will keep growing in the future, since the indicators are expected to increase in the forthcoming years. In this perspective, we also considered the variable "Average Age", which is relevant to our analysis for two reasons: first, Schupp (2015) found that this variable is useful in explaining the geographical diffusion of FMs by using data more precise than the ones used to perform the above regression and, second, this variable is expected to have a greater impact in the future, when baby boomers' aging will affect US households' consumption patterns (Knickman and Snell 2002).

FIGURE 2 • AGGREGATE DEMAND FOR U.S. FMS: PROJECTION OF MAIN DRIVERS. INDEX NUMBERS (2015 = 1).



Data Source: Our elaboration based on Nowak and Walton (2005); U.S. Census Bureau (2010).

Another factor influencing the diffusion of FMs is the quantity of farming operations. After 1974, the quantity of U.S. farms tended to stabilize around low negative rates after fifty years of steady decline (Sexton 2013) and, during the past decades, both the number of farms and arable land followed a linear negative trend, while the average farm size increased. This behavior reflects two sides of the same phenomenon: the impact of the process of urbanization and the effect of specialization and consolidation of the farming sector.

This first attempt to define the different variables affecting FMs diffusion is still rough and needs deeper analysis. Nevertheless, such preliminary assessment reveals some important insights for the aim of this paper: both socio-demographic variables (population density, age, households size) and the structure of the farming sector (number of farms) impact the distribution of FMs across the Country. Moreover, the urbanization process behaves as a cross variable, influencing both FMs diffusion (higher demand) and farm closings (declining supply). The second point merits particular attention, because urbanization (especially in the form of urban sprawl) has the highest impact on peri-urban areas, where increasing land values and increasing competition for commercial land use compromise the viability of small-farm operations, which represent the stock of "adopters" that are most likely to join a FM (Holloway and Kneafsey 2004).

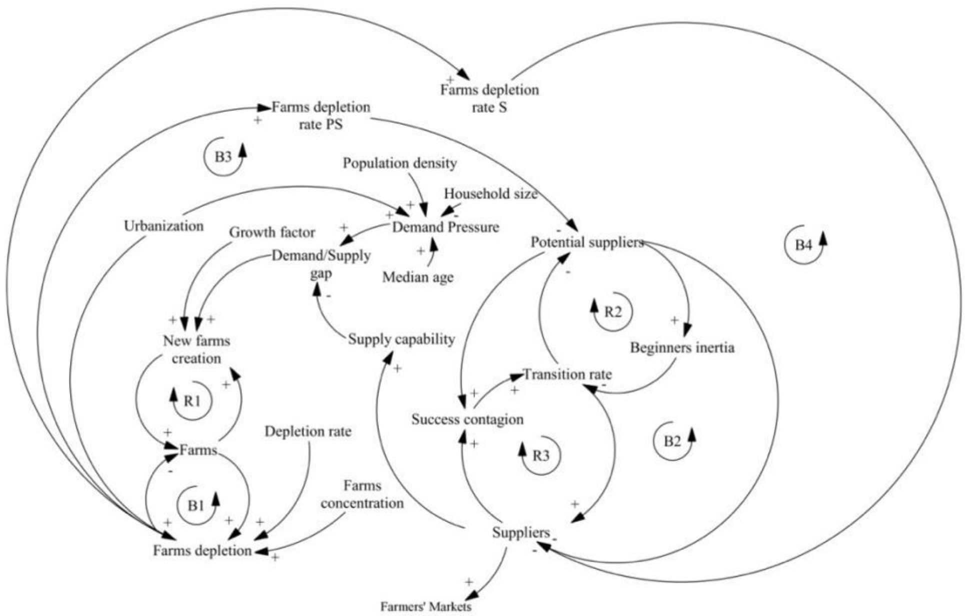
3. Methods and model description

System dynamics is a method developed in the mid of the 1950s (Forrester 1958). Originally conceived for the analysis of business cycles (Forrester 1976), its use was soon extended to environmental modeling and socio-economic simulations (Sterman 2000; Meadows *et al.* 1972; Ford 1999). The main goal of a system dynamics model is not to predict the future, but to "*link the past to the present by showing how present conditions arose, and extend the present into persuasive alternative features under a variety of scenarios determined by policy alternatives*" (Forrester 1993: 19). Thanks to their flexibility, system dynamics models are a valuable framework for effective, quantitative storytelling, where categories and semantics are chosen according to the researcher's goal (Guhathakurta 2002). While several researches have investigated production choices among farmers from a systemic point of view (Shi and Gill 2005; Rozman *et al.* 2009; Li *et al.* 2012), such approach has not yet been implemented for retailing strategies like direct marketing, FMs or more generally AFNs.

3.1 The Model: Causal Loop Diagram

According to the concepts introduced in the previous paragraphs, the model implemented considers two main dynamics affecting the diffusion of FMs in the US: the diffusion of social innovations through the adoption/diffusion model (Bass 1992; Sterman 2000) and several structural trends affecting both the demographic and the farming systems. The first stage for the implementation of a system dynamics model is to define the causal relationships involving the variables considered in order to explain a certain phenomenon. This results in a causal loop diagram (CLD) explaining the mechanisms driving the development of FMs according to the diffusion of social innovations among both consumers and producers (Fig. 3).

FIGURE 3 • CAUSAL LOOP DIAGRAM



Labels in Fig. 3 represent the causal variables associated with the diffusion of FMs as forms of social innovation. Each label is connected to the others through lines specifying the direction of the causality (arrows) and the effect on the subsequent variable (a reinforcing effect is denoted by the sign "+" , while a negative correlation is denoted by "-"). The capital letters indicate the networks of causal mechanisms behaving as reinforcing ("R") and balancing ("B") feedback loops. System dynamics is a useful tool to represent the complex interactions underlying the functioning of feedback loops, where a change in a variable is transmitted through a circuit of causal events which eventually reinforce or balance the initial effect on the first variable. For example, looking at "R3" it is easy to recognize the reinforcing mechanism involving the variables "suppliers", "success contagion" and "transition rate": more suppliers involved in FMs increase the perception of FMs as successful strategies for other farmers, which in turn increase the rate of adoption of such strategy, which, again, increases the number of suppliers and so on. As in every modeling approach, it has been necessary to introduce few relevant assumption about the functioning of the causal system above represented. The three assumptions presented in Tab. 2 allow to better focus on the mechanism of diffusion of FMs.

TABLE 2 • MAIN ASSUMPTIONS INCLUDED IN THE MODEL

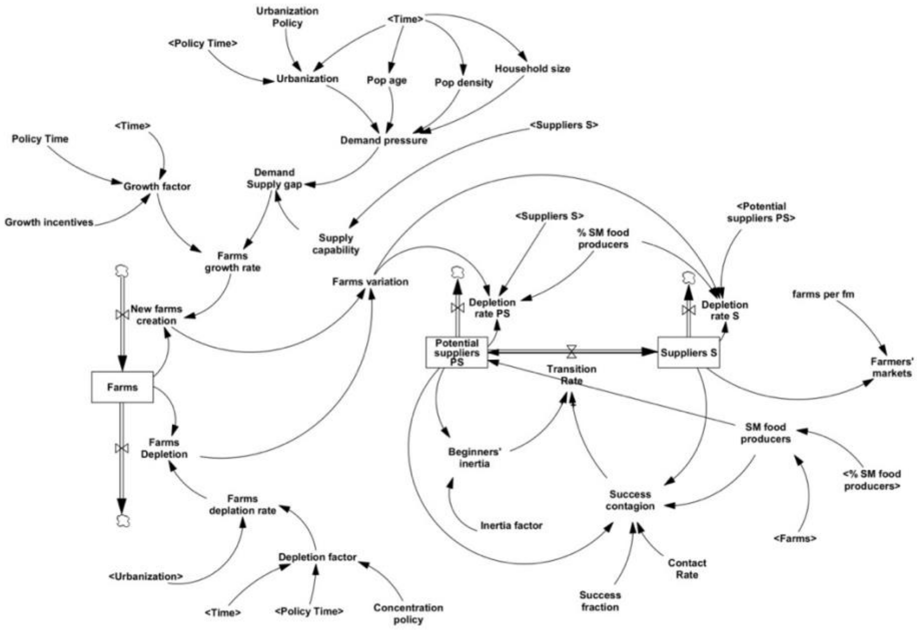
a) Demand for locally grown food is higher than current supply and its evolution follows the evolution of population dynamics, urbanization rate and household's size.
b) There are no delays affecting farmers' decision to join or to quit a FM
c) Only small and medium family-owned operations producing fresh food and/or diary products can sell their products at FMs

Once the network of causal mechanisms at play in the determination of the phenomenon considered has been defined, it is possible to proceed towards its mathematical formalization.

3.2 The model: stock-flow diagram

The model is based on a set of equations regulating the size of three stocks at a particular point in time (1994): Farms, Potential Suppliers and Suppliers. Five equations define the flows associated with the three stocks (Tab. 3). Figure 4 shows the stock-flow diagram of the model through the interface of the Vensim® simulation software.

FIGURE 4 • STOCK-FLOW DIAGRAM



The first stock parameter is the aggregate quantity of farming operations in the US, whose initial value was equal to 2,1 million units in 1994 (USDA 2014). The second stock equation links the number of potential adopters, defined by the total amount of small and medium farms producing food suitable for direct marketing (fresh food, diary, etc.), with the total amount of suppliers, which are the farmers who decided to form or to join a local FM. According to the USDA (1994), 86,432 farms were selling their products directly to consumers in 1994, but only 20,946 farmers were reported as FMs vendors (Payne 2002). By contrast, a more recent estimate conducted by Ragland and Tropp (2009) found that in the early stages of FMs expansion in the U.S., the average number of vendors per market was 31. We used the latter figure to estimate the number of FM vendors for the year 1994, according to the number of operative FMs provided by USDA FMs count. Following Ragland and Tropp's argument, during the recent period of growth in the number of FMs, the quantity of vendors per market decreased to 22. We included also this value in the model.

TABLE 3 • THE MODEL: STOCK AND FLOW EQUATIONS

Stock equations				
Name	Description	Equation	Initial Value	Source

Farms	Total amount of U.S. farms	INTEG (+ New farms creation-Farms Depletion)	2.10E+06	USDA (2014)
Potential suppliers PS	Number of farms satisfying the criteria for being FMs suppliers	= INTEG (-Transition Rate+Depletion rate PS)	(SM food producers - Suppliers S)	/
Suppliers S	Number of farms selling their products at FMs	INTEG (Transition Rate+Depletion rate S)	51,750	Our elaboration based on Ragland and Tropp (2009) and USDA (1994)

Flow equations		
Name	Description	Equation
New farms creation	Number of farms created each year	Farms growth rate*Farms
Farms depletion	Number of farms closed each year	Farms*Farms depletion rate
Variation rate PS	Yearly variation in the number of Potential Suppliers	"% SM food producers"*Farms variation* (Potential suppliers PS / (Suppliers S+Potential suppliers PS))
Variation rate S	Yearly variation in the number of Suppliers	"% SM food producers"*Farms variation* (Suppliers S / (Potential suppliers PS+Suppliers S))
Transition Rate	Number of potential suppliers that each year become suppliers	Beginners' inertia + Success contagion

Several endogenous variables define the set of relationships within the stocks and the flows (Tab. 4). The time step chosen for the simulation is equal to one year and the period under investigation corresponds to 50 years, starting from 1994.

TABLE 4 • THE MODEL: ENDOGENOUS VARIABLES

Name	Description	Equation
Farms growth rate	The rate of growth of new farms	Growth factor*Demand/Supply gap
Demand pressure	The structural trend of the demand	Household size + Popage + Popdensity+Urbanization
Supply capability	The trend of the supply	Suppliers S/Initial Value "Suppliers"
Demand/Supply gap	The gap between the trend of the demand and the trend of the supply	Demand pressure/Supply capability
Farms depletion rate	The rate of farm closings	Depletion factor*Urbanization
Farms variation	The difference between farms openings and closings	New farms creation-Farms Depletion
Beginners' inertia	Conformism and skepticism that counter-act the imitation of pioneers	Inertia factor*Potential suppliers PS
Success contagion	Imitation factor, more pioneers attract more potential suppliers, overcoming the negative effect of initial skepticism	Contact Rate c*Success fraction*Potential suppliers PS*SuppliersS / SM food producers

SM food producers	Number of small and medium farms producing food for direct consumption	Farms*"% SM food producers"
Farmers' markets	Total amount of operative FMs	Suppliers S/farms per fm

3.3 Model calibration

To establish whether the model is able to represent the complex phenomena under investigation or not, it is necessary to calibrate some control variables and compare the outcomes of a first simulation to the observed data available (1994-2016). According to Hoppe (2014), the number of small farms producing vegetables, fruit, dairy and poultry (thus excluding both big businesses and commodity-specialized farms that use mediators in the supply chain, as in the case of cash crops, beef, hogs or other livestock producers), is equal to 205,812 units. This value, referred to the year 2012, corresponds to nearly 10% of all US farms. It is important to underline that the "Beginners' inertia" and the "Success contagion" factors are two components of the adoption/diffusion model as introduced by Bass (1969) and further developed by Sterman (2000) in a system dynamics perspective. The variables "Contact rate", "Success factor" and "Inertia factor" have been chosen arbitrarily. These values represent: (1) the number of farmers met every year by each FM supplier ("Contact rate"); (2) the number of farmers that every year decide to form or join a FM ("Success factor"). In this case a very low imitation factor has been chosen, indicating that in order to persuade a new farmer to join a FM, it takes at least three years (or three suppliers to persuade one potential supplier in only one year); (3) the number of farmers that every year decide to leave a FM is given by the variable "Inertia factor". In this case, the value is very high, since many farmers may attempt several times to join or form an FM, but often these experiences result unsuccessful (Stephenson *et al.* 2008). Finally, the net rate of farm openings, given by the difference between farm openings and closings, can be considered as a constant, which value has been observed at -0.8% per year during the past decades (USDA 2014).

TABLE 5 • THE MODEL: EXOGENOUS VARIABLES AND FUNCTIONS

Name	Description	Value/Equation	Source
	Constants		
% SM food producers	Percentage of small and medium farms producing food for direct consumption	0.10	Own elaboration based on Hoppe (2014)
Contact Rate c	Number of farmers contacted by one supplier during one year	81	Assumption

Success fraction	Imitation factor among potential suppliers	0.0043	Assumption
Inertia factor	Skepticism among potential suppliers	-0.077	Assumption
Farms per FM	Average number of farms per FM	22	Ragland and Tropp (2009)
Depletion factor	Historical factor of farm closings, depending on concentration processes	IF THEN ELSE(Time>=Policy Time, Concentration policy*0.015 , 0.015)	USDA (2014)
Growth factor	Historical factor of farm opening	IF THEN ELSE(Time>=Policy Time, Growth incentives*0.007 , 0.007)	USDA (2014)
Exogenous functions			
Household size	Average size of U.S. households, projected trend	IF THEN ELSE (Time>0, (-0.286*LN(Time) + 3.6863) / 3.6863 , 3.6863/3.6863)	Own elaboration on US Census Bureau (2010)
Pop age	Average age of U.S. citizens, projected trend	IF THEN ELSE (Time>0, (1.4578*LN (Time) + 36.784)/36.784 , 36.784/36.784)	Own elaboration on US Census Bureau (2010)
Pop density	Average population density in U.S., projected trend	(9e-005*EXP (0.0056*Time))/ 9e-005	Own elaboration on US Census Bureau (2010)
Urbanization	Average urbanization rate in U.S., projected trend	IF THEN ELSE (Time>=Policy Time, Urbanization Policy* (0.0251*EXP(0.0177*Time))/ 0.0251, (0.0251*EXP(0.0177*Time))/ 0.0251)	Own elaboration on Nowak and Walton (2005)

3.4 Model validation and baseline scenario

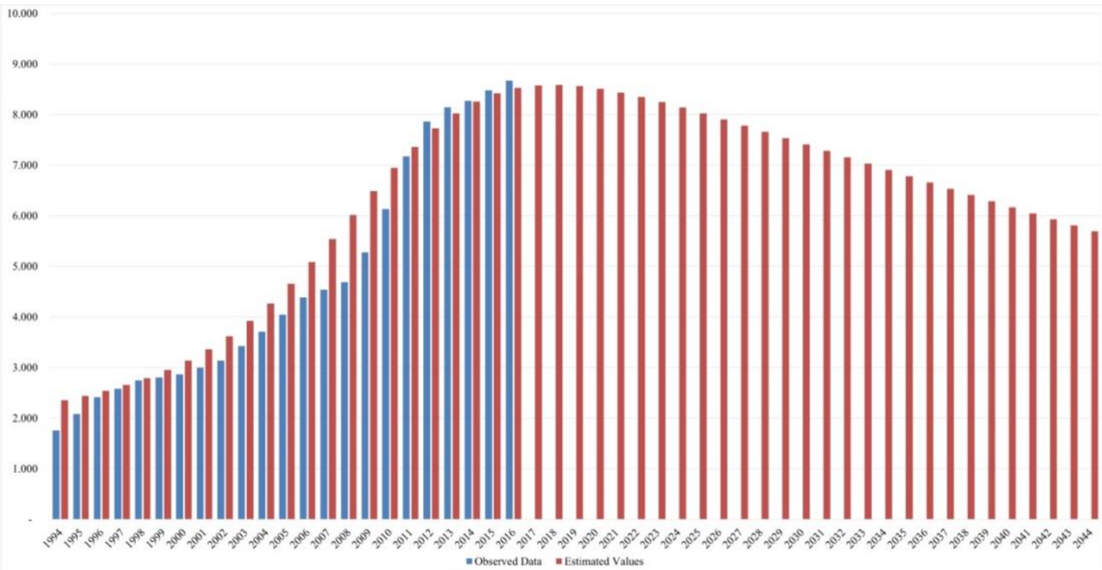
In order to check the validity of the model, the national count of US FMs provided by the USDA has been used as a benchmark for the period 1994-2016. Fig. 5 shows the observed (blue) and the estimated (red) values for the number of FMs. The model results reliable, with a coefficient of determination (R_2) equal to 93.7%, and a mean absolute error equal to 387 (10.7% in relative terms). A sensitivity analysis has been performed for three exogenous variables which values were arbitrarily assigned. The results show that in some cases the number of FMs is sensitive to a variation in our assumptions. Nevertheless, the analysis showed only a numerical sensitivity, while no evidence was found for either a behavioral sensitivity nor a policy sensitivity.

TABLE 6 • THE MODEL. SENSITIVITY OF (±10%) CHANGE IN THE ASSUMPTION ABOUT THE VALUE OF THREE VARIABLES ON THE NUMBER OF FMS

	Negative 10%			**Positive 10%**		
	FMs average	*% change*	*Sensitive*	*FMs average*	*% change*	*Sensitive*
Success fraction	4990	-21.38%	Yes	6576	3.61%	no
Contact rate	4990	-21.38%	Yes	6576	3.61%	no
Inertia factor	5758	-9.28%	No	6509	2.55%	no

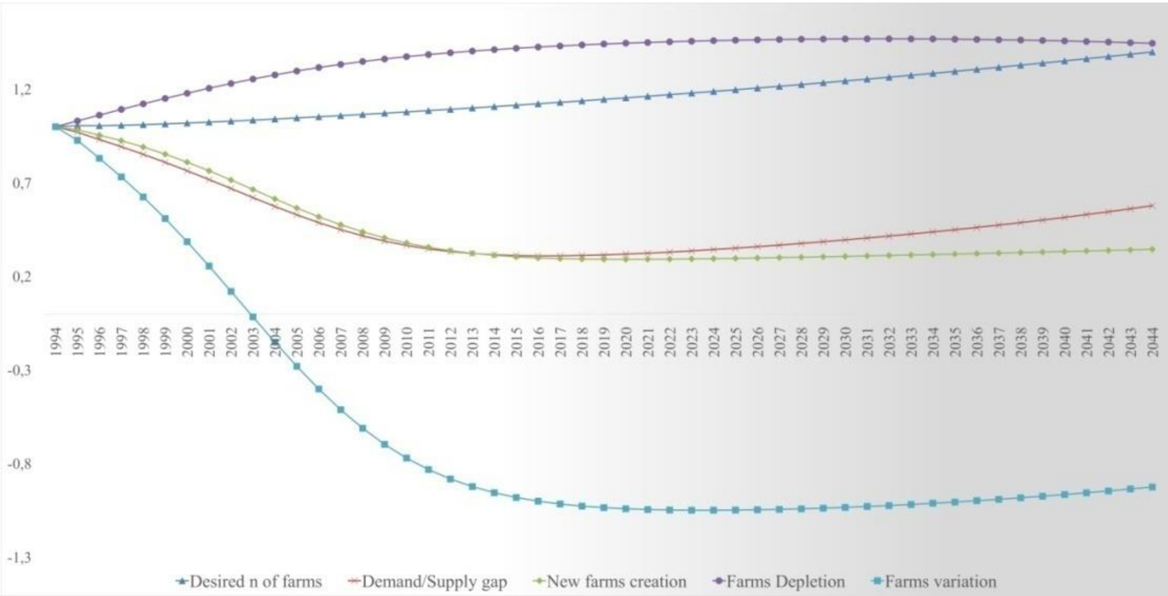
Fig. 5 shows the outcome of the system (number of FMs) after the simulation of a baseline scenario. According to the initial conditions provided, the total amount of FMs in the US increases until a certain peak, then it declines. This behavior is due to the fact that the increasing urbanization (as projected in Fig. 3) in the long term leads to the depletion of a greater quantity of land, reinforcing farm concentration and thereby increasing the rate of farm closings. Such an explanation allows to consider the rate of urbanization as a major leverage point of the system implemented. Furthermore, it supports the initial hypothesis that the current trend in FMs diffusion might be determined by the decreasing availability of suppliers.

FIGURE 5 • BASELINE SCENARIO:
TOTAL NUMBER OF FMS IN THE U.S. SIMULATED (RED) VS. OBSERVED (BLUE) DATA



While demand saturation may occur in many towns, villages and neighborhoods, the national aggregate demand might be still compatible with another expansion of FMs. This view is confirmed by observing the simulation's results in terms of efficiency of the supply in satisfying the demand (Fig. 6). While the demand pressure increases steadily, the number of operative farms drops, determining the ineffectiveness of the systems in providing urban food needs ("Demand/Supply gap").

FIGURE 6 • BASELINE SCENARIO, MAIN INDICATORS' TREND (1994-2044).
VALUES IN SHADED AREA ARE PROJECTIONS

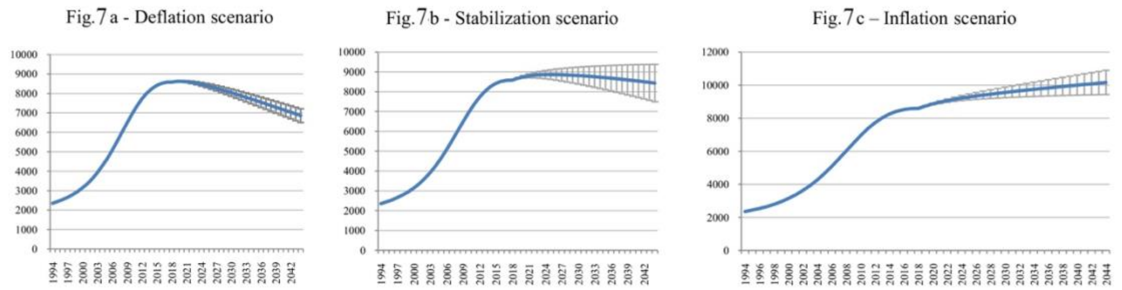


4. SCENARIO ANALYSIS

Three leverage points have been selected as potential targets of policy intervention in order to conduct the scenario analysis: the growth rate of new farms; the closing rate of existing farms; the urbanization rate. The alternative scenarios have been projected starting from the year 2017 through the activation of three external variables denominated "policy time". Three hypothetical policy tools are therefore oriented to stimulate the growth of new farms (G), to reduce the concentration of existing farms (C) and to reduce the urbanization rate (U). The magnitude of the policy intervention is set equal to three different levels: no-policy, low-policy and high-policy, resulting in different changes in the values of U, G and C. Policies oriented to boost the opening of new businesses can have an effect ranging from +30% (low-policy) to +80% (high-policy), whereas policies oriented to decrease the concentration of farms or the urbanization factor can range from -30% (low-policy) to -80% (high-policy) on a year-by-year basis. The combination of the three variables at three different levels of implementation (zero, low and high policy) gives as a result 24 scenarios including the baseline one. All the scenarios improved the baseline projections. However, the majority of the simulations fail to further increase the diffusion of FMs over the 2016

level. Therefore, the first consideration emerging from the scenario analysis is that the chosen set of policies oriented to promote the development of AFNs in the US has low effectiveness. The second consideration relates to the factors determining this behavior: because of the structure of the adoption/diffusion model, the number of small and medium farms interested in selling their products at FMs can no longer grow exponentially after that the majority of the "potential adopters" becomes "suppliers". Another consideration follows: the range of policies considered in the analysis does not entail dramatic changes in the structure of US farming system, therefore the opportunity space for the development of new cycles of innovation is limited. By considering what emerged from the simulations, we propose a scenario analysis based on the 23 scenarios grouped into three sets of alternative outcomes:
The first set – defined as "deflation scenarios" (Fig. 7a) – includes the scenarios giving a negative outcome at the end of the simulation. Fig. 7a shows the average between the six trends projected and the standard deviation. Policies allowing this evolutionary pattern should be considered as ineffective.
The second set includes the "stabilization" scenarios (Fig. 7b) for which the outcome variable (number of FMs) is more or less equal to the number of FMs observed at the beginning of the simulation. Seven scenarios compose this set which could be defined as a set of solutions oriented to mitigate the negative impact of farms concentration and urbanization on the diffusion of Fms.
The third (Fig. 7c) set includes nine scenarios of inflation. Through the implementation of a particular set of policies, the number of US FMs in the future could keep increasing, although at a linear rate.

FIGURE 7 • SCENARIOS' CLASSIFICATION BASED ON THE AVERAGE OUTCOME.
BOXES REPRESENT THE MAGNITUDE OF THE POLICY INTERVENTION (WHITE = ZERO; LIGHT GREY = LOW-POLICY; DARK GREY = HIGH-POLICY). GREY BARS ARE STANDARD DEVIATION



	Policies deflation						Policies stabilization							Policies inflation									
	1	5	3	6	13	15	4	7	9	10	16	17	18	19	2	8	11	12	14	18	20	21	22	23
u																								
g																								
c																								

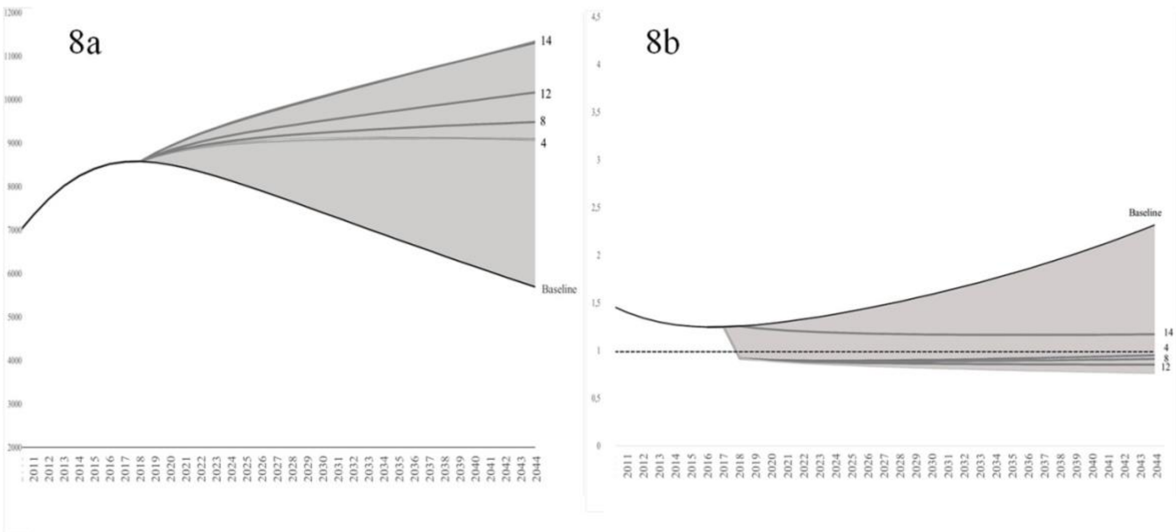
4.1 Scenario analysis: effectiveness

The analysis of the three groups of scenarios reveals some interesting insights: (1) scenarios focusing on the implementation of only one of the three policy tools at a low level resulted ineffective in expanding the diffusion of FMs. If taken one at a time, a small stimulus to the growth of new farms, a limited control of urban sprawl or the slight limitation of farms concentration resulted ineffective. (2) The implementation of more radical policies (±80%) is a condition necessary but not sufficient to undertake a scenario of inflation. For example, a strong stimulus to the growth rate of new farms could be totally ineffective if not coupled with policies constraining the rates of urbanization and farmland concentration. Strong policies oriented to increase the variable "G" require at least one additional policy intervention in order to be effective. A similar discourse applies to the variable "U" and "C". (3) The most sensitive policy-variable is "C". In fact, almost all the policies involving high changes in "C" (-80%) are effective in increasing the number of FMs in the long period. (4) While the most effective scenario entails a joint intervention on the three policy-variables, it is interesting to underline that a similar result could be achieved through a strong policy intervention on only two variables: farms concentration ("C") and new farms growth rate ("G").

4.2 Scenario analysis: efficiency

By examining the outcome of the simulations, it is possible to assess the efficiency of the system after the implementation of different sets of policies. The whole system is considered efficient when both demand pressure and supply dynamics follow the same pattern. Thus, in conditions of increasing demand, an efficient system shows an increasing supply, while an inefficient system will be unbalanced, with a growing gap between the supply and the demand dynamics. In the model implemented, this behavior is represented by the variable "Demand/supply gap", which reflects an efficient equilibrium when its value is near to one, whereas the system results unbalanced. Fig. 8b presents the range of values of the variable "Demand/supply gap" obtained for the 23 simulated scenarios.

FIGURE 8 • SCENARIO ANALYSIS: RANGE OF EFFECTIVENESS (8A) AND EFFICIENCY (8B). BASELINE SCENARIO, S14, S12, S8 AND S4. EFFICIENCY THRESHOLD = 1.



The baseline scenario shows a dynamic efficiency that increases throughout the period 1994-2015. For later periods, the gap between the structural trend of the demand (increasing) and the supply (decreasing) makes it more and more difficult for US FMs to correctly meet the demand for locally grown food. Only seven scenarios bring the system towards a constant efficient condition or a linear improvement in efficiency over time. Scenarios where the gap between demand and supply is constant are only partially efficient, while scenarios where the gap is increasing, are considered inefficient. On the other hand, scenarios presenting a gap between demand and supply that tends towards the threshold value can be considered as efficient (s14, s4, s12, s8). One of the most efficient scenarios (s4) is not effective in increasing the number of FMs over time (Fig. 8a). By contrast, the outcome of scenarios s8, s12 and s14 revealed both efficient and effective. Scenario s14 is particularly effective in increasing the number of FMs and in pursuing dynamic efficiency on the long period. This scenario shows that the best mix of policies for achieving a sustainable and efficient pattern of growth should be based on strong incentives to create new farms combined with a strong policy intervention oriented to reduce farms concentration.

5. Policy implications

Through the simulation of 23 different scenarios, we showed that US FMs could still increase in the future through the adoption of three different policies:

1. Policy instruments oriented to increase the farms growth rate: this category includes economic subsidies, private and public programs oriented to improve young people's interest towards agriculture, promotion of cooperatives and other mutualistic structures to sustain start-up initiatives, promotion of urban farming.
2. Policy instruments oriented to decrease the rate of closings of existing small and medium farms, such as: measures contrasting financial speculation on agricultural land, discouraging crop monocultures near urban areas, offering financial assistance to small businesses or policies encouraging multifunctional agriculture practices entailing diversification and positive externalities.
3. Policy instruments oriented to reduce the rate of urbanization: for instance, through the creation of "green belts" around urban areas, the limitation of financial speculation on built land, the limitation of urban-sprawl, the protection of the agricultural landscape through the creation of rural and peri-urban protected areas.

In the case of the best performing scenario both in terms of effectiveness and efficiency (s14), an example of integrate policy may include the introduction of a new scheme of economic incentives to remunerate the social, cultural and the ecosystem's services provided by small and medium farms located in peri-urban contexts (Depietri *et al.* 2016) to stimulate the openings of new farms, and the gradual shift from subsidies schemes from capital-intensive to labor-intensive operations, in order to contrast farmland concentration. However, as mentioned above, the most effective scenarios do not allow another S-shaped expansion of US FMs. In fact, to obtain a new wave of exponential growth, a major change in the structural dynamics of US farming system, such as, for example, the inversion of the process of farmland concentration would be necessary, although unrealistic. In sum, policies may help the development of FMs to consolidate as market niches, but the analysis proposed in this article did not find evidence that AFNs may further scale-up in the forthcoming years, enabling a major paradigm shift. The short list of hypothetical policies here proposed is certainly not exhaustive, yet it provides some useful examples to open the debate on the future role of FMs, AFNs and, more generally, the potential goals of policy proposals oriented to strengthen the role of local food systems.

CONCLUSIONS

This article investigated the evolution of AFNs aiming to assess whether such experiences may be considered as the preliminary phase of a paradigmatic shift from the conventional, standardized form of mass retailing systems toward a new form of urban-rural relation or not. By adopting a definition of AFNs as forms of social innovations, the article analyzed the recent trend in the development of FMs in the US and the causal mechanisms sustaining it. A quantitative analysis has been performed through the implementation of a system dynamics model. Preliminary results confirm that the number of FMs in the US is currently stabilizing after a period of exponential growth. The simulation showed that the last expanding phase peaked in recent years, and another exponential growth of U.S. FMs will not be possible in the future given that the number of potential suppliers (small and medium farms producing food suitable for direct marketing) is limited. While the lack of additional potential adopters due to the characteristics of the US farming system hinders another phase of exponential growth, there is still potential to increase the number of FMs in a linear way if the net rate of opening of new small businesses is increased. The model developed in this study considered three leverage points (farms growth rate, farms concentration rate and urbanization rate) as targets of policy-intervention. 23 scenarios simulated by introducing alternative sets of policy intervention showed that the most effective and efficient way to sustain the future growth of FMs in the US includes high incentives to the opening of new farms (in order to increase the quantity of potential suppliers) and the parallel reduction in the rate of land concentration (to increase the resilience of small businesses). Although proposals for more radical reforms may re-boost the process of diffusion of AFNs in the US, from the analysis here proposed it seems correct to conclude that such experiences are close to reach their maximum development as forms of market niches without having the possibility to scale-up as new paradigms. This last point adds a relevant contribution to the recent debate on the definition of AFNs as actual "alternatives" to conventional retailing systems and urban-rural relations (Sonnino and Marsden 2005). The model developed within this study suffers numerous limitations, especially for what pertains the strong assumptions introduced and the under-representation of the complex set of relationships driving the behavior of both consumers and farmers. However, further enquiries may refine this preliminary framework in order to better assess the nature and the prospects for the future development of AFNs in different contexts.

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