UNIVERSITÀ DEGLI STUDI DI TORINO

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Exploring Microcredit in China: Insights from an Agent-Based Simulation Model

Supervisor:

Prof. Pietro Terna

Co-supervisor:

Prof. Sergio Margarita

Candidate:

Maddalena Saccone

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To Michelangelo, with all my love

Contents

Introduction

Since 2008, China has been slowing down; the growth rate is now 7%. However, this country is still playing an extremely influential role in the global economy. With the second largest number of poor in the world after India, a rural society which occupies roughly 55% of the whole population, a number of small and medium-sized enterprises which represent 99% of all businesses, and the dramatic lack of access to formal finance for many of these, China represents an ideal candidate for implementing microcredit services, which may help rebalancing its economy. Given the large-scale migration of the poor from rural areas to the rapidly industrializing cities, which is further deepening income inequalities and causing massive social disruption, the Chinese government has been promoting the provision of financial services aiming at supporting economic development in rural areas. Microfinance is starting to play a crucial role, and it seems to promote three basic principles: *dai nü bu dai nan; dai xiao bu dai da; dai qiong bu dai fu,* meaning *lend to women, not to men; lend small amounts, not large amounts; lend to the poor, not the wealthy.*

For these reasons we will consider China as a theoretical benchmark for our work, which tries to address the potential role of microcredit as a tool for poverty alleviation and its social impact through the development of microenterprises. In particular, we are going to test whether microcredit may be a way to fill structural holes, by creating qualified microenterprises with specific competencies. In fact, in a developing context, which is likely to be characterized by small enterprises specialized in solving problems day by day, structural holes corresponds to problems related to the ordinary functioning of the productive activity. For instance, if a machinery breaks down, it might happen that there is no one able to repair it, and thus the production process must stop.

Our work is organized as follows: in Chapter 1 we present an historical overview of microcredit in China, followed by a review of the literature and theorizing concerning the role of microcredit in rural areas, the social role of microenterprises (with a

particular focus on the ones led by women), and the role of Guanxi networks in China; in Chapter 2 we discuss the method chosen to analyse these insights, i.e. a combination of agent-based simulation modelling and network analysis, adopting the analytical tool of the “recipe”; in Chapter 3 we describe our model, which tries to exploit the insights highlighted in Chapter 1 by simulating an abstract developing country, and the experiments; in the final section we present a discussion of the results and suggestions for future research.

Chapter 1

Microcredit: Focus on China

1.1 WHAT IS MICROCREDIT?

Originally, the notion of microcredit was introduced to indicate very small loans to poor people, aiming at financing income-generating investments. Then, the notion of microfinance was added in order to designate a broad range of financial services, including not only microcredit, but also microsavings and microinsurance, to mention just a few. According to Gert Van Maanen (2004), microcredit is about "banking the unbankables", i.e. providing credit to those individuals who cannot be served by regular banks, since they do not meet the minimal requirements for receiving formal credit, concerning collateral, steady employment, income and verifiable credit history, and quite often also because it is too expensive for banks to loan such small amounts. Quoting Muhammad Yunus, a Bangladeshi economist who founded the Grameen Bank in 1983, considered the father of microcredit:

> (Microcredit) is based on the premise that the poor have skills which remain unutilized or underutilized. It is definitely not the lack of skills which make poor people poor….charity is not the answer to poverty. It only helps poverty to continue. It creates dependency and takes away the individual's initiative to break through the wall of poverty. Unleashing of energy and creativity in each human being is the answer to poverty.

Indeed, the basic idea of Yunus is that each person has the potential to become an entrepreneur and that credit should be promoted as a human right. According to the Grameen approach, the main features which make microcredit differ from traditional lending are:

- Targeting the poor. Microcredit programmes have the specific purpose to target poor and low-income groups.
- Collateral free. Microcredit offers poor people the possibility of having collateral-free loans. Indeed, it is likely that they do not own valuable assets and thus this way of minimising default risk would lead to excluding them from lending.
- Group lending. It is based on the notion of joint liability, which creates a sort of "social collateral" that reduces the costs of monitoring borrowers and ensures repayments (Anderson and Nina, 2000; Besley and Coate, 1995). In fact, according to the group lending scheme, each individual borrower is a member of a borrowing group and assumes responsibility for the repayment of the others. If one member of the group defaults, all the group members will be not allowed to receive microcredit loans in the future.

Microcredit plays a crucial role since it significantly contributes to poverty alleviation. As Gert Van Maanen (2004) points out, "credit is a door opener that brings a whole spectrum of development within reach", including not only a higher income level, but also better nutrition, clothing and housing, self-empowerment, lower child mortality, better education and health care for children. Thus, it reduces the vulnerability of the poor to external shocks (illness, weather, etc.).

However, microcredit is not a panacea for poverty. Indeed, poverty is a multidimensional concept. According to the OESO-DAC (2001), "poverty denotes people's exclusion from socially adequate living standards and it encompasses a range of deprivations" which are related to human capabilities. In particular, poverty encompasses the following dimensions:

(1) The economic dimension, related to income, livelihoods, decent work.

(2) The human dimension, related to health and education.

(3) The political-juridical dimension, related to empowerment, rights, voice.

(4) The social-cultural dimension, related to status and human dignity.

(5) The security dimension, related to insecurity, risk and vulnerability.

Thus, microcredit should be promoted as a part of a wider poverty eradication strategy, combined with other intervention programmes such as social protection programmes (Chowdhury, 2004).

1.2 HISTORY OF MICROFINANCE IN CHINA

Since the implementation of market reforms in 1978, China has shifted from a centrally planned to a market based economy, experiencing a massive economic boom and social development. With a population of 1.3 billion, the country has become the second largest economy and has achieved significant progress in poverty reduction and rural development (ADB, 2008). For instance, rural poor has declined from 250 million in 1978 to 26 million in 2004 and official poverty dropped from 15 percent in 1984 to 2 percent in 2007 (Rahman and Luo, 2011).

Nevertheless, China remains a developing country, given that its per capita income still represents a fraction of that in advanced countries.

According to official data, China had about 98.99 million people still living below the national poverty line of RMB 2,300 per year at the end of 2012. With the second largest number of poor in the world after India, poverty reduction remains a fundamental challenge, as highlighted by the following statement: "reducing poverty among the remaining 'hard-core' poor, has increasingly become an uphill battle" (UNDP, 2001).

In addition, China's financial sector is still underdeveloped, although some progress has been made. In particular, thanks to the development of non-state banks, microfinance institutions (MFIs) and non-bank financial institutions, financial services have been extended to areas in which state-owned banks were not so involved, allowing financing underdeveloped regions and Small and Medium Enterprise (SMEs). It has to be said that the potentiality of microcredit in China is huge, given that the country has large rural populations, unemployed workers, SMEs, MSEs, little rural coverage, high loan to deposit ratio of formal financial institutions (He, 2008). Unfortunately, there are obstacles preventing the microfinance sector from reaching its full potential, including unclear regulatory environment, the presence of barriers to market freedom and business restrictions (NGO-MFIs, Lending Companies, MCCs are restricted to collect deposit).

1.2.1 Financial Sector Development

According to Rahman and Luo (2011), in order to understand the gradual development of the financial sector, it is useful to consider the development of standard banking sector and microfinance sector, which are analysed in the following sections. It is worth stressing that, while the banking sector is already close to the maturity stage, the microfinance sector is still at the learning stage.

1.2.1.1 Banking sector development

As illustrated in Figure 1, the development of traditional banking sector can be divided into the following three main phases:

1.2.1.1.1 Development phase I: 1978-1983

Before 1978, China's financial system was represented by a single, monopolistic bank: the People's Bank of China (PBC). It functioned as central and commercial bank, it was owned by the government and controlled by the Ministry of Finance.

The turning point occurred in 1979, when the government established four specialized banks: the Agricultural Bank of China (ABC) for rural financing, the People's Construction Bank of China (PCBC) for investment and manufacturing financing, the Bank of China (BOC) for international transactions and the Industrial and Commercial Bank of China (ICBC) for working capital financing, formed in 1984. In addition, PBC formally became China's central bank, thus a two-tier banking system-made by a central bank and state-owned specialized banks (SOBs)-emerged.

1.2.1.1.2 Development phase II: 1984-1993

During this phase, Non-bank Financial Institutes (NBFIs), such as Trust and Investment Companies (TICs), finance companies, leasing companies, management companies, postal saving banks, insurance companies and securities companies, were allowed to compete with the "Big Four" state-owned banks.

Moreover, Regional banks were created in the Special Economic Zones (SEZs), Rural Credit Cooperatives (RCCs) were established in rural areas under the control of ABC,

serving Township and Village Enterprises (TVEs) and households, and Urban Credit Cooperatives (UCCs) were formed in urban areas.

1.2.1.1.3 Development phase III: 1994-to date

In the last phase, China's financial system started a process of liberalization and internationalization, opening to microfinance. Several reforms were introduced; in particular it was legalized that state-owned specialized banks could be converted to privately-owned commercial banks (Shirai, 2002). In 1995, the new commercial bank law was promulgated and gave the central bank more autonomy by allowing operations in a market environment under the control of the State Council. Hence, thanks to the reforming process, the government control over the financial sector was reduced, PBC started playing a more indirect influence and the credit ceiling of financial institutions was abolished.

It is worth noting that, since 1995, foreign banks have been respecting the national rules concerning Renminbi business (Hofman, 2009). However, in 1999 geographical and customer restrictions of RMB business on foreign banks started to be relaxed, and, after China's entrance into WTO in 2001, they were abolished in 2006, as well as non-prudential restrictions.

The international community recognizes the progress China has been making from an economic and financial standpoint, in fact, an increasing number of foreign banks are moving into China or are looking for business cooperation and partnerships (CBRC, 2007).

As reported by Rahman and Luo (2011), even though China's banking sector has many limitations, it has demonstrated its efficiency and potentiality during profound financial crises in 1997 and 2008.

Pre-reform period, prior to 1979	
Until 1979	▪ Monobank system. The People's Bank (PBC) functioned as central and commercial bank
Phase I: 1979–1983	
1979	▪ Established four State-owned specialized banks-
	▪ ABC for rural financing
	▪ PCBC for investment financing
	▪ BOA for international financial transactions
	▪ ICBC for working capital financing (established in 1984)
1981	▪ The first treasury bonds were issued and sold on a compulsory basis
1983	▪ Two-tier banking system created
	▪ Central bank created out of the PBC
	▪ Competition allowed among the state owned specialized banks
Phase II: 1984–1993	
1984	▪ Control over RCCs shifted from PBC to ABC
	▪ RCCs begin servicing TVEs and households independently
	▪ The selected new banks were permitted to operate alongside these four banks
1985	▪ Financing responsibilities shifted from government to banks
	▪ Foreign banks were permitted to set up branches
1986	▪ Provisional bankruptcy law passed for SOEs
	▪ Local interbank centers have emerged
1987	▪ Nonbank financial institutions were allowed for business
	▪ Competition among all banks and nonbank financial institutions were allowed
1991	▪ Separated commercial and policy-based lending
	▪ market interest rates were allowed
	▪ Encouraged banks to do better loan assessment and portfolio management
Phase III: 1993 to date	
1993	▪ Refinance facilities from PBC restricted
	▪ State-owned specialized banks converted into real commercial banks
	▪ Diversified financial market established
	▪ Restrictions on lending to non-priority sectors were eased
	▪ Comprehensive reforms introduced
1994	▪ Three policy banks established to provide policy loans
1995	▪ New commercial bank law was enacted
1996	▪ Established an interministerial coordination group for rural financial system reform
1998	▪ All specialized banks allowed financing all sectors in rural areas
	▪ Allowed foreign banks access to domestic inter-bank offering market
1999	▪ Relaxing the geographical and volume restrictions of RMB business for foreign banks
2001	▪ China's accession to WTO
	▪ Foreign banks were allowed to undertake foreign currency business
2003	▪ Foreign banks were permitted to undertake corporate RMB business
2004	▪ RMB business was opened to foreign banks in five cities
2005	▪ RMB business was opened to foreign banks in seven cities
2006	▪ Geographical and customer restrictions of RMB business on foreign banks were removed
	▪ The non-prudential restrictions on foreign banks' operations in China were removed

Figure 1: Chronological development of banking sector in China, CBRC (2007), Mehran (1996), Hofman (2009), Shirai (2002), Meyer (2000), Laurenceson (2003).

1.2.1.2 Microfinance sector development

China has been providing microfinance services for twenty-two years, since their introduction in October 1993 as a policy tool for poverty reduction. Referring to Rahman and Luo (2011), it is possible to distinguish three basic phases in the development process of microfinance:

1.2.1.2.1 Development Phase I: 1994-1998

The first phase can be considered as an experimental phase since microfinance activities were very limited and began to develop through projects mostly relying on international grants and soft loans, i.e. loans with a below-market rate of interest.

Before 1994, several international foreign-aid projects were developed with government collaboration; for instance they were implemented by: United Nations Women Development Fund (UNWDF) for creating employment opportunities for women, International Foundation for Agricultural Development (IFAD) for increasing food supply and improving the nutrition level of middle and low income rural households, United Nations Population Fund (UNFPA) for revolving capital and Hong Kong Oxford for delivering credit to rural households for livestock farming and veterinary services (Druschel, 2002).

At the end of 1993, the first experiment of implementing the Grameen Bank methodology was conducted by Chinese Academy of Social Sciences (CASS); clients were poor rural women in Yixian County, Hebei Province; Nanzhao County, Henan Province; Yucheng County, Henan Province; and Danfeng County, Shaanxi Province.

As far as donor funded microfinance programs are concerned, in 1995, a microfinance project was conducted by UNDP at Yilong County, Sichuan Province. Then it has expanded to 48 counties of 17 provinces, becoming one of the biggest microfinance projects supported by an international organization in China.

Several international and national organizations started implementing microfinance in China; for instance the United Nations Children's Fund (UNICEF) in 1996, followed by World Vision (WV) in 1997, the United Nations Population Fund (UNFPA) in 1998, The Canada-China Women's Income Generating Project (CC97) in 1997, Oxfam Hong Kong in Yunnan province since 1992, the China Foundation for Poverty Alleviation (CFPA) in 1997 and Rural Credit Foundations (RCFs).

Since the 1990s, also the government has been playing a crucial role in supporting microfinance in rural areas through the Agricultural Bank of China (ABC) and the Agricultural Development Bank of China (ADBC), while Rural Credit Cooperatives (RCCs) have been dealing with township and village enterprises (TVEs) and middle-income male farmers (Du, 2002; Zhu et al., 1997). In 1996, RCCs, which represent the first government bank offering microcredit to farmers, officially became independent (Watson, 2002).

1.2.1.2.2 Development Phase II: 1999-2004

During this phase, formal financial institutions entirely participate in microfinance and projects are institutionalized. In 1999, RCCs launched microcredit loans and group loan business for rural households.

Nowadays, RCCs represent the most active microfinance practitioner in China. Then, since 2002, microfinance expanded from rural to urban areas, thanks to central government initiatives aimed at encouraging local government to support the laid-off unemployed people, which were allowed to start-up funds and working capital so as to self-employ (Tang, 2009).

1.2.1.2.3 Development Phase III: 2005-to date

The last phase can be considered as the phase of normalization and institutionalization of microfinance, shaping the regulatory framework of China's microfinance.

In 2005, the PBC made the popularity of microfinance grow by introducing microloan companies in Sichuan, Guizhou, Shanxi, Shaanxi and Inner Mongolia provinces, (Tang, 2009).

In 2005, China Association of Microfinance (CAM) was established. It was made by domestic MFIs, relevant administrative departments, domestic and international organizations, and experts and scholars supporting microfinance. According to CAM (2010), its main functions are: policy coordination, self-regulation, technical assistance and training, information exchanges, and fundraising services.

Since 2006, China Banking Regulatory Commission (CBRC) has been allowing postal saving banks to offer collateral-based microloan services, and domestic commercial banks and rural cooperative to establish fully-owned lending companies such as Village and Township Banks (VTBs), Lending Companies (LC) and Rural Mutual Credit Cooperatives (RMCCs). Moreover, since 2007, CBRC fostered microloan companies and all banking financial institutions to offer microcredit to households, rural enterprises and sole proprietors. In 2008, CBRC also allowed individual, corporate legal entities and social organizations investment to establish microloan companies.

Towards the end of 2009, the amount of loans provided by the seven major microfinance institutions was more than 18.6 billion USD.

Before 1994	
Before 1994	▪ International foreign-aid projects with government collaboration- ▪ UNWDF for creating employment opportunities of women ▪ IFAD for improving food supply and increasing the nutrition level of middle and low income rural households ▪ UNFPA for revolving capital, and ▪ Hong Kong Oxford for livestock farming and veterinary services
Phase I: 1994–1999	
1994	▪ the first experiment of Grameen Bank model was implemented in China
1995	▪ UNDP undertook a microfinance experiment project
1996	▪ UNICEF started microfinance activities ▪ RCCs officially became independent entities
1997	▪ World Vision (WV) began offering microfinance services ▪ Established Rural Credit Foundations (RCFs) ▪ CIDA, Canada-China Women's Income Generating Project
1998	▪ UNFPA began microfinance activities
Phase II: 1999–2004	
1999	▪ RCCs introduced microcredit loan and group loan businesses
2001	▪ PBC promulgated the Guidance on Microcredit Loans Management of RCCs
2002	▪ PBC widely promoted microcredit loans for rural households across the country ▪ Established reemployment guarantee foundation
2003	▪ Tax-credit rating management methodologies" issued by State Administration of Taxation
2004	▪ Improvement in Granting Microfinance Loans and Serving the Rural Poor'
Phase III: 2005 onward	
2005	▪ PBC launched pilot credit-only for microloan companies ▪ Established China Association of Microfinance (CAM)
2006	▪ Pilot Management to Strengthen Postal Savings Bank management ▪ Eased Market Access for Banking Financial Institutions
2007	▪ CBRC promulgated the Guideline on How to Greatly Develop Rural Microloan Business
2008	▪ allowed individual, corporate legal entities and other social organizations investment

Figure 2: Chronological development of Microfinance sector in China, He Guangwen (2009), MFIT (2008), CAM (2008), Tang (2009), Sun (2008), Druschel (2002).

1.3 Structure and Regulation of Microfinance in China

1.3.1 Operational Bodies

As Figure 1 illustrates, the three main operational bodies which promote microfinance in China are:

(1) **NGOs, international organizations and social organizations.** International organizations have been delivering financial services with the collaboration of government agencies, including microcredit as well as other services, such as savings, training, and so on. Funding the Poor Cooperative (FPC) is one of the largest Chinese microfinance organisations, making microcredit available especially to poor women, in the rural areas of Hebei, Henan and Sichuan Provinces. The China Foundation for Poverty Alleviation (CFPA) also operates some microfinance

projects, as well as some rural development associations managed by United Nations Development Programme (UNDP) and China International Center for Economic and Technical Exchanges (CICETE). The funds typically come from international multilateral or bilateral aid agencies or from World Bank in the form of soft loans. Unfortunately, in this field there might be some challenges, such as limited capital sources, lack of standard financing channels, inadequate professional managerial talents and low project management level.

(2) Financial institutions. The main formal microfinance service providers -mostly state-owned- are: Agricultural Bank of China (ABC), Agricultural Development Bank of China (ADBC), Rural Credit Cooperatives (RCCs), Rural Cooperative Bank, Rural Commercial Bank, Postal Savings Bank of China (PSBC), China Development Bank (CDB), VTB, Microloan Companies (MCCs) and Rural Mutual Credit Cooperatives (RMCCs). Besides, some international financial institutions, such as Grameen Trust, BlueOrchard Finance and ACCION International, have begun to collaborate with domestic institutions, such as CDB and Alibaba. The main microfinance method used by the ABC and the ADBC is group lending adopted by Grameen Bank, and borrowers are mostly peasants. Rural Credit Cooperatives, Rural Cooperative Banks and Rural Commercial Banks, also adopt other microfinance methods, such as microcredit and collateral loan. Unfortunately, many of these institutions suffered a loss, due to the high cost, high risk and upper limit of interest rate.

(3) Government agencies. Many policy microfinance projects are operated jointly by government agencies and financial institutions with the aim of subsidizing loans for poverty alleviation and reemployment of urban laid-off workers. For instance, Urban Credit Bank (UCB) has been active in spreading microcredit services to urban areas.

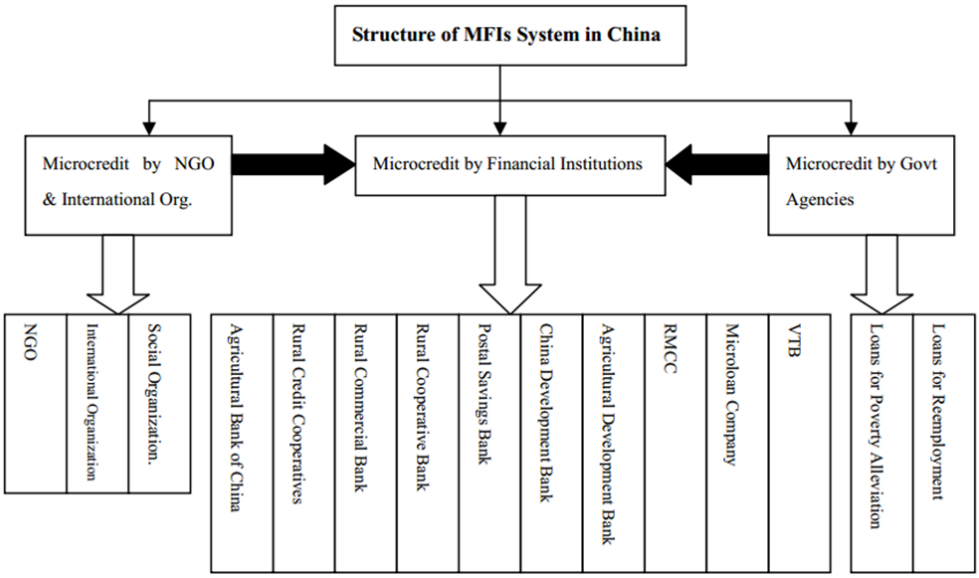


Figure 3: The Structure of Microfinance System in China, He Guangwen (2009).

1.3.1.1 Comparative features of microcredit suppliers

Figure 4 illustrates the comparative features of different microcredit suppliers.

Referring to Rahman and Luo (2011), since NGO-MFIs and MCCs are non-financial institutions, they are not permitted to deal with savings-as well as lending companies-nor receive money from commercial banks (CAM, 2008).

Besides, rural financial institutions, such as VTBs, LCs, RMCCs, and MCCs are subjected to geographical restrictions.

The traditional collateral system is still practiced by several service providers, such as MCCs, micro-lending companies, lending companies, postal saving banks and VTBs, while RCCs and UCBs require collateral for large loans and companies guarantee respectively.

The donor funded MFI projects, such as UNDP, UNFPA, UNICEF, Heifer Project, World Vision, Oxfam Hong Kong and CIDA, provide microcredit services by collaborating with government departments or agencies satisfying certain conditions.

Type of institutions	inception	Coverage	Beneficiaries	Collateral	Interest rate	Savings	Remittances
NGO-MFI	1993	Country-wide	Mid-low income and poor clients	No	3-18	no	No
ABC	1997	Country-wide	Mid-low income and poor cliets	No	2-3	No	No
RCCs	2000	Country-wide	All farm households	No. but yes for large loans	0.9-2.3 times basic rate	Yes	Yes
UCB	2002	Urban areas	Laid off workers	Guarantee companies	Basic rate with subsides by government	Yes	Yes
MCCs	2005	5 provinces	Farmers and microenterprises	Yes	Around 20	No	No
VTBs	2006	6 provinces	Farmers and microenterprises	Yes	0.9-2.3 times basic rate	Yes	No
RMCCs	2006	6 provinces	Member farmers and micro enterprises	No	0.9-2.3 times basic rate	Yes	No
Lending companies	2006	6 provinces	Farmers and micro-enterprises	Yes	0.9-2.3 times basic rate	no	No
Poverty alleviation loans	2006	country-wide	Mid-low income and poor clients	No	Less than basic rate	Yes	Yes
Postal savings	2007	Country wide	All farm households	Yes	0.9-2.3 times basic rate	Yes	Yes
Commercial Bank	2005	More than 10 regions	Micro-enterprise and disadvantages people	No	Around 20	yes	Yes
Donor funded MFI projects and others							
UNDP	1995	17 provinces	Group lending	no	8	yes	-
UNFPA	1998	13 provinces	Farm households and groups, also training	no	8.77	no	-
UNICEF	1996	13 provinces	Women clients and training	no	9.6	yes	-
Heifer Project	1985	13 provinces	Farm households	no	6	no	
World Vision	1997	1 province	Farm households	no	4		
Oxfam Hong Kong		Country-wide	Village	no	Community decided	yes	-
CIDA	1997	1 province	Farm households	no	7-10	yes	-

Figure 4: Comparative features of microcredit service providers, CAM (2008), Druschel (2002), Tang (2009).

1.3.2 Microfinance regulation

China Banking Regulatory Commission (CBRC) is the agency authorised by the State Council to regulate banking and MFIs sectors in China. China Association of Microfinance (CAM) also tried to build microfinance regulations with the collaboration of China Academy of Social Sciences (CASS), but it had to suspend because the government refused to provide authorization (Sun, 2008).

Nowadays, the problem is that the Chinese regulatory system is incomplete (Du, 2005). Nevertheless, CBRC has been providing favourable guidelines for microfinance development. For instance, it relaxed interest rates and strongly encouraged microloan companies, village banks, commercial banks, NGO-MFIs to provide microfinance services. Thus, in 2008, 77 million household could benefit from microfinance services, and, according to CBRC (2009), 583 microfinance companies have started their

businesses in China. In 2011, 91 village banks, 9 farmers' funding, 9 microcredit companies (7 domestic and 2 foreign) along with City Commercial Bank, ACLEDA, XAC Bank, and Grameen Bank were providing financial services in China.

Recently, government has decided to subsidize banks for the higher risk of lending to SMEs (World Bank, 2009, CBRC, 2009), in order to further expand the financial market in China.

According to Rahman and Luo (2011), the most important regulations in favour of microfinance industries are:

(i) *The creation of business opportunities to national and international NGO-MFIs.*

(ii) *Interest rate guidelines.* According to the CBRC, the lending rates should not be greater than the ceiling established by the central bank and not be lower than 0.9 times the benchmark rates.

(iii) *Loan services guidelines.*

- *Loan area.* Each loan area-such as agricultural area, consumer area, medical treatment, children's tuition, entrepreneurship, migrant workers, start-up businesses-has its own guidelines.
- *Loan size.* In developed regions, the microcredit loan size can be increased to 100,000-300,000 RMB ($1470-$4412), while in less developed regions it can be increased to 10,000-50,000 RMB ($1470-$7353). Other regions can decide loan size but within the abovementioned range.
- *Loan procedure.* Microcredit suppliers always try to simplify microloan procedures in rural areas, such as applications procedures, loan processing time, using credit line cards, and to increase the convenience level of borrowing.

However, the Chinese regulatory framework is still unclear. Without any doubts, banks and MFIs have different goal orientations, thus, it is of utter importance that authorities conduct a balanced policy regulation in order to foster the sustainability of microfinance sector.

According to Prof. Muhammad Yunus, founder of Grameen Bank, building a separate authority should be a priority. There should be a separate regulatory authority for MFIs

as distinguished in character from that for the commercial banks. The regulatory authority for MFIs should evolve guidelines keeping in view the objectives of socio-economic development of the poor.

According to UNDP (2005), the lack of a comprehensive legal and regulatory framework is the major obstacle for microfinance development in China.

1.4 MICROCREDIT IN RURAL AREAS OF CHINA

In this section, we focus on microfinance in rural areas since the rural society in China represents more than a half of China's population, roughly 55%.

1.4.1 Poverty in rural China

As Turvey and Kong (2008) point out, in developing countries hundreds of millions of households live in a state of chronic poverty and food insecurity, especially in rural areas.

This is particularly true in the Chinese context, characterized by endemic rural poverty, deep food insecurity, and a significant income gap between rural and urban households.

Undoubtedly, China has achieved significant improvements in the fight against poverty since 1978. As Figure 1 illustrates, the population of rural poor and the headcount rate-the proportion of population living below the poverty line-dropped steadily. However, the annual decrease of population of rural poor slowed down gradually in more recent years. The fastest reduction in poverty occurred during the initial phase of the rural reforms from 1978 to 1984, when the number of rural poor dropped from 250 million to 128 million. Poor people dropped by 2.82 million in 2001, 1.07 in 2002, while in 2003 they increased by 80 thousand mostly because of natural disasters.

Year	Poverty line (Yuan/person)	Population of rural poor (million)	Headcount rate (%)
1978	100	250	30.7
1984	200	128	15.1
1985	206	125	14.8
1986	213	131	15.5
1987	227	122	14.3
1988	236	96	11.1
1989	259	102	11.6
1990	300	85	9.4
1992	317	80	8.8
1994	450	70	7.7
1995	530	65.4	7.1
1997	640	49.6	5.4
1998	635	42.1	4.6
1999	625	34.1	3.7
2000	625	32.1	3.4
2001	630	29.2	3.2
	872[2]	90.3	9.7
2002	627	28.2	3.0
	869	86.5	9.2
2003	637	29.0	3.1
	882	85.2	9.1

Figure 1: Poverty Statistics in China from 1978 to 2000, Rural Survey Organization of National Bureau of Statistics (2004)

Figure 2 and Figure 3 present income class frequencies of rural households over the period 1995-2004. The first four columns show actual frequencies, while the last four columns show cumulative frequencies.

In 2004, 15.05 per cent of rural households earned less than 1300 yuan in net disposable income each year, 48.11 per cent had annual net disposable income of less than 2500 yuan, and only 18.94 per cent earned more than 4500 yuan per year.

	Frequencies				Cumulative frequencies			
	1995	2000	2003	2004	1995	2000	2003	2004
Below yuan 100	0.21	0.31	0.49	0.40	0.21	0.31	0.49	0.40
100-200	0.36	0.20	0.18	0.13	0.57	0.51	0.67	0.53
200-300	0.78	0.43	0.31	0.21	1.35	0.94	0.99	0.74
300-400	1.47	0.69	0.52	0.31	2.82	1.63	1.51	1.05
400-500	2.30	1.01	0.78	0.53	5.12	2.64	2.29	1.58
500-600	3.37	1.37	1.19	0.85	8.49	4.01	3.48	2.43
600-800	9.54	4.44	3.25	2.43	18.03	8.45	6.73	4.86
800-1000	11.63	5.72	4.87	3.64	29.66	14.17	11.60	8.50
1000-1200	11.83	6.75	5.52	4.04	41.49	20.92	17.13	12.54
1200-1300	5.38	3.75	2.97	2.51	46.87	24.67	20.10	15.05
1300-1500	9.74	7.42	6.39	5.11	56.61	32.09	26.49	20.16
1500-1700	7.92	7.48	6.45	5.69	64.53	39.56	32.93	25.85
1700-2000	9.39	10.45	9.39	8.57	73.92	50.01	42.32	34.42
2000-2500	10.29	14.54	13.79	13.69	84.21	64.56	56.11	48.11
2500-3000	5.89	10.29	10.81	11.76	90.10	74.85	66.92	59.87
3000-3500	3.49	7.11	8.02	8.85	93.59	81.95	74.95	68.72
3500-4000	1.95	4.76	5.84	7.09	95.54	86.71	80.79	75.81
4000-4500	1.34	3.44	4.20	5.25	96.88	90.15	84.99	81.06
>4500	3.12	9.85	15.01	18.94	100.00	100.00	100.00	100.00

Figure 2: Distribution of rural household income in China from 1995 to 2004, Turvey and Kong (2008)

[2] Higher poverty line, “low-income line”.

Figure 3 depicts the cumulative effect, highlighting that rural household income has significantly increased over the past few years. However, poverty and food insecurity are still a dramatic problem for many.

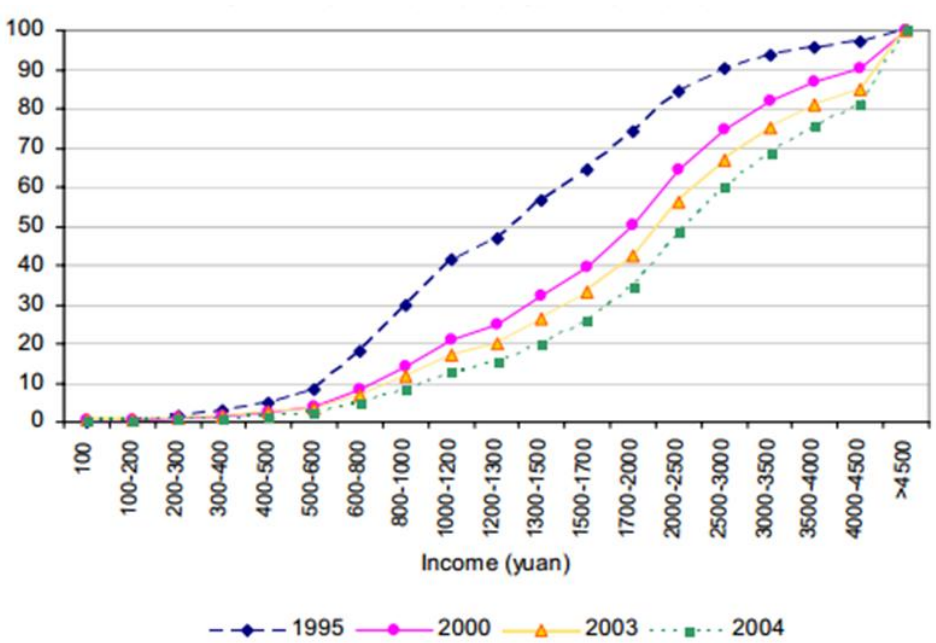


Figure 3: Cumulative index of net disposable income of rural households, Turvey and Kong (2008)

Figure 4 highlights the classification of rural households into five income groups. It is worth stressing that low-income rural households (in the first column) represent about 80 per cent of all households; hence lower-middle-income, middle-income, upper-middle-income and high-income households represent about 20% of all households.

	Household level of income:				
	Low	Lower middle	Middle	Upper middle	High
Persons per household	4.60	4.34	4.10	3.86	3.50
Per capita annual income (yuan)	8,182.71	11,576.04	14,494.61	18,469.91	31,114.69
Per capita annual net income (yuan)	4,631.60	7,994.24	10,571.81	13,925.61	24,257.28
Consumption expenditure	5,742.14	6,861.51	8,000.97	9,493.87	14,451.91
Food	3,194.11	3,650.44	4,043.05	4,506.68	5,652.06
All other goods and services	2,548.03	3,211.07	3,957.93	4,987.19	8,799.84
Cash consumption expenditure	3,935.56	4,991.19	6,147.24	7,713.41	12,986.94
Food	1,501.88	1,902.67	2,314.40	2,850.31	4,275.44
All other goods and services	2,433.68	3,088.52	3,832.84	4,863.09	8,711.50
Food consumption deficit (cash expenditures on food - food expenditures)	-1,692.23	-1,747.77	-1,728.65	-1,656.37	-1,376.63
Total deficit (cash - consumption expenditure)	-1,806.58	-1,870.32	-1,853.73	-1,780.47	-1,464.97
% Deficit on food	0.94	0.93	0.93	0.93	0.94
Approximate % of population	0.80	0.20			

Figure 4: Consumption expenditure of rural households, classified by income level, in 2004, Turvey and Kong (2008)

Net income is obtained by subtracting household expenses, including production inputs, from household income. For all income groups, including high-income households, consumption expenditures are higher than cash consumption expenditures, i.e., there is a deficit in the amount of cash required for consumption, ranging from -1,747.77 to -1,376.63. Since there is not a pure food insecurity measure, Turvey and Kong (2008) consider both the total deficit and the food consumption deficit. The food consumption deficit represents about 94 per cent of the total deficit, meaning that rural households are able to cover general household expenditures but the remaining income is not enough to satisfy food consumption needs.

Hence, food insecurity results in a persistent poverty trap, from which it is hard to escape if there are no opportunities for growth.

In addition to that, the position of rural households relative to urban households is rapidly diminishing.

Figure 5 provides an historical overview of the income gap between urban and rural households in China.

As we can see from the last column, in 1978 rural household income was about 38.9 per cent of urban household income; then there have been some significant improvements between 1980 and 1990, due to the rapid growth of industrial sectors. However, since the implementation of some reforms in 1991, the gap has risen again: in 2004 rural income was only 31.2 per cent of urban income.

Year	Annual net income of RURAL households (per capita)		Annual disposal income of URBAN households (per capita)		Rural/urban household income ratio
	Value (yuan)	Index	Value (yuan)	Index	
1978	133.6	100.0	343.4	100.0	0.389
1980	191.3	139.0	477.6	127.0	0.401
1985	397.6	268.9	739.1	160.4	0.538
1989	601.5	305.7	1373.9	182.5	0.438
1990	686.3	311.2	1510.2	198.1	0.454
1991	708.6	317.4	1700.6	212.4	0.417
1992	784.0	336.2	2026.6	232.9	0.387
1993	921.6	346.9	2577.4	255.1	0.358
1994	1221.0	364.4	3496.2	276.8	0.349
1995	1577.7	383.7	4283.0	290.3	0.368
1996	1926.1	418.2	4838.9	301.6	0.398
1997	2090.1	437.4	5160.3	311.9	0.405
1998	2162.0	456.2	5425.1	329.9	0.399
1999	2210.3	473.5	5854.0	360.6	0.378
2000	2253.4	483.5	6280.0	383.7	0.359
2001	2366.4	503.8	6859.6	416.3	0.345
2002	2475.6	528.0	7702.8	472.1	0.321
2003	2622.2	550.7	8472.2	514.6	0.310
2004	2936.4	588.1	9421.6	554.2	0.312

Figure 5: Annual per capita net disposable income and Engle coefficient of urban and rural households from 1978 to 2004, Turvey and Kong (2008)

Figure 6 depicts histograms, providing a visual glimpse of the gap between China's rural poor and the urban elite in terms of disposable income over a more recent period. Consistent with the tendency highlighted in Figure 5, Figure 6 shows that the gap has kept increasing: in 1990 the annual per capita net disposable income of rural and urban households were respectively 686.3 and 1510.2 yuan, compared with 2013 when they were 8895.9 and 26955.1 yuan.

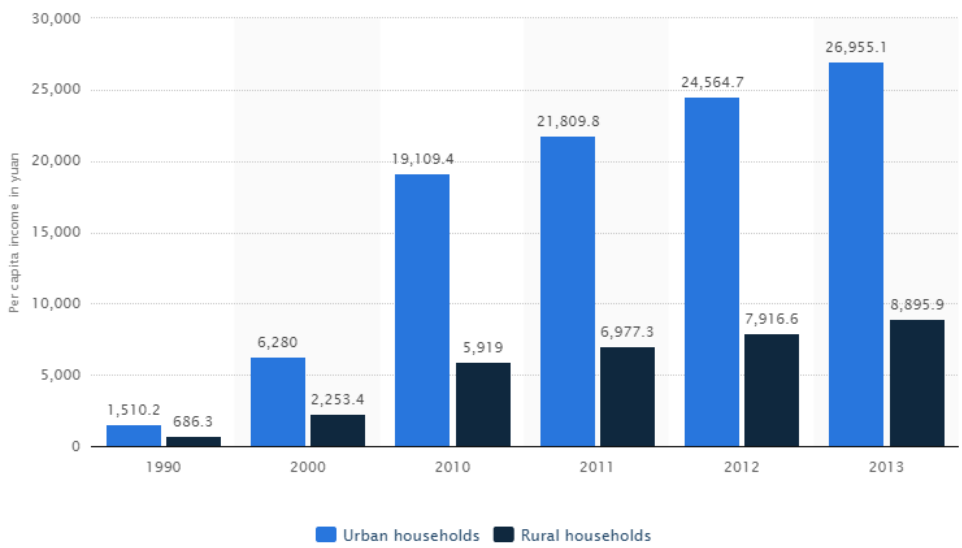


Figure 6: Annual per capita net disposable income of rural and urban households in China from 1990 to 2013 (in yuan), National Bureau of Statistics of China (2014)

1.4.2 Credit accessibility by rural households and informal lending

According to Guo and He (2006), the absence of adequate formal finance determines an increase in informal finance. They are imperfect substitutes, but without any doubt the inadequacy of supply in the former makes the latter grow. As Guo and He (2006: 3) highlight, "the shackle of rural economic development is the scarcity of capital". Indeed, the lack of access to formal credit prevents rural households from increasing production and leads to the stagnant growth of the rural economy (Park, Ren, and Wang, 2004; Cheng and Xu, 2003).

Indeed, credit has been rationed to the poor and they have been excluded from formal financial service because the prevailing belief was that they were not creditworthy, had limited or no collateral at all, and did not produce enough income to repay a loan.

It is only recently that the traditional notion of creditworthiness has started to be challenged.

In fact, what has become evident is that the most vulnerable people, languishing in a persistent poverty trap, are those who lack physical and financial resources. Physical resources include fixed resources such as land and buildings, which can enhance economies of size, and variable inputs such as seed, feed and fertilizer, which can contribute to economies of scale. Financial resources, instead, consist of capital necessary to buy physical resources.

According to the prevailing view in literature, the poverty trap is mainly driven by the financial or credit constraint, which prevent people from acquiring physical resources and thus expand their production and improve their living conditions. For instance, in China farmers need credit support to meet their living needs but also to purchase fundamental inputs such as chemical fertiliser that are necessary for China's soils which are not particularly fertile and need extra nutrients.

In addition to that, there might also be significant constraints on physical resources. Indeed, China's current system of collective land ownership has prevented farmers from accessing traditional credit support from formal financial institutions because farmland cannot be bought or sold, hence farmers cannot use it as collateral which is a necessary requirement in traditional lending. Therefore, China should not rely on western-style credit rating, given that most of borrowers do not have property rights over collective

lands. In fact, if that system is considered, then credit markets would split into collateral-based and noncollateral based on usury, trust or both.

Due to the impossibility to access formal credit, rural households have been relying mostly on informal lending. In China, informal lending cannot be measured easily since it not only includes illegal private banks (or moneylenders) but also free credit, i.e. transactions between friends or relatives. Moneylenders are usurious informal lenders who increase farmers' indebtedness by charging exorbitant interest rates. Thus, they contribute to the deterioration of the financial conditions of rural households, keeping them trapped in poverty. For example, in the northeast and northwest areas of China, informal lending rates of 100% to 200% annually are quite common (Linton, 2008). However, according to Han (2004), approximately 50% to 60% of rural households in China still rely on informal credit for their consumption and production.

Guo and He cite several studies according to which informal finance for rural households in some Chinese provinces ranges from 24 per cent to 95 per cent of loans outstanding and stressing that in some districts informal borrowing is about 70 per cent of rural households' total debt. Guo and He point out that the monetary intensity of informal lending to rural households ranges between 1.89 and 2.6 times formal lending. These numbers were even higher considering all loans in China, including urban areas, thus we can conclude that informal credit is absolutely predominant in China.

As far as the repayment rates on informal credit are concerned, Guo and He (2006) stress that only 30 per cent of poverty alleviation loans issued by the Agricultural Bank of China are repaid. It is not clear whether it is due to abuse or inability. If inability is the cause, then it would be enough to re-engineer repayment terms in order to meet the temporal needs of the poor. Moreover, to avoid default, recourse must be real, hence farmers won't default since this would affect future borrowing.

He and Li (2005) present survey data on informal lending in Guizhou province. Given that the break point between legal and usury interest rates is 40 per cent, only 19.33 of borrowers from informal lenders knew of rates below 40 per cent, 80.67 per cent knew of rates above 40 per cent and 23.1 per cent knew of rates above 100 per cent. Actually, only 13.5 per cent of rural households accepted loans at usury rates above 40 per cent, because either formal lending was absent or it did not provide the amounts required.

Moreover, according to He and Li (2005), free credit from family and friends is more frequent and crowds out moneylenders, and these findings are confirmed by Huo and Quo (2005).

Actually, according to their results, it is not completely clear whether credit from friends or relatives at no or little interest derives from a cultural rule or from credit rationing. However, in reality it seems that informal lending is driven by an inadequate supply of capital for agricultural and rural investments.

Lei and Li (2006) reported similar findings based on a survey in Taian city, Shandong province, according to which 107 out of 135 rural households used informal credit such as borrowing from relatives, friends and moneylenders, while only 47 rural households obtained loans from the RCC.

Similarly, Huang and Wen (2006), considering 140 rural households in Xinyu City, found that 82.6 per cent obtained money from informal lending, mostly from relatives with no or low interest.

1.4.3 The role of Microcredit in fighting rural poverty

Financial access to all social groups, especially to the poor, has started playing a crucial role in the fight against poverty and inequality in many developing countries around the world (Rahman and Luo, 2011).

As Turvey and Kong (2008) highlight, Microcredit was introduced as a counter model for a non-collateral economy, in contraposition to the credit-rationing model based on collateral developed by Stiglitz and Weiss (1981: 393).

The diffusion of microcredit and microfinance institutions (MFIs) throughout the developing world has led to important improvements in some rural communities, concerning rural entrepreneurship, production expansion, growth, income enhancement, poverty gap reduction and food vulnerability (Hartarska and Holtmann 2006; Meyer and Nagarajan 2006; Zeller 2006).

Since 1986, the Chinese government tried to expand credit access by rural households through targeted subsidised-loan programmes, in order to raise rural incomes, improve agricultural production, and develop rural areas. Nevertheless, most of the subsidised loans were allocated to the rich, township enterprises, or industrial projects supported by local government, rather than poor rural households. In addition, subsidised loans were financially unsustainable due to the low repayment rates (less than 50%) (Heilig et al., 2006; Park and Ren, 2001).

Given the failure of subsidised loans in reaching rural households, microcredit was introduced in China as part of the government's poverty alleviation programmes in the mid-1990s.

In order to understand rural microfinance practices in China, Xi et al. (2009) introduced four microfinance models for the market of low-income group or people at Bottom of the Pyramid (BOP) in rural China. These models are: the model of microcredit for rural household, the model of co-guarantee loans of rural household, the model of innovative mortgage loans and the model of third-party involvement loans.

1.4.4 The model of microcredit for rural household

The basis of the model of microcredit for rural household is given by their credibility. Indeed, financial institutions provide the loans to farmers according to the approved amount limit and duration without mortgage or security. According to this model, first some propaganda concerning microcredit in rural areas is made, then credit rating groups are formed, they determine the amount limit and issue the microcredit license to rural households on the basis of an evaluation of their economic situation.

As shown in Figure 7, the main steps are as follows:

(1) Village leaders provide small credit loans to rural households

(2) Village leaders provide credit information concerning rural households to Financial Institutions

(3) Financial Institutions provide small credit loans to rural households

(4) Rural households pay back principal and interest to Financial Institutions

Village leaders play a crucial role in this model since they are closely related to villagers and know their economic situation. They allow financial institutions to correctly evaluate the credit rating of rural households and decrease the lending risk. In fact, together with members of the credit rating group, village leaders help financial institutions to obtain information concerning the number of members of the household, the number of workers, the health status, total income and net income, whether they own their house or other properties and their ordinary behaviour.

This model is convenient for rural households since principal and interest repayments are flexible, but, having no mortgage, financial institutions face high lending risk. Therefore, according to this model it is difficult for rural households to receive a loan

and, if they get it, the credit amount is low (for most financial institutions the amount limit is 500 RMB-about $730- while for only a few of them it is 10000 RMB-about $1460-).

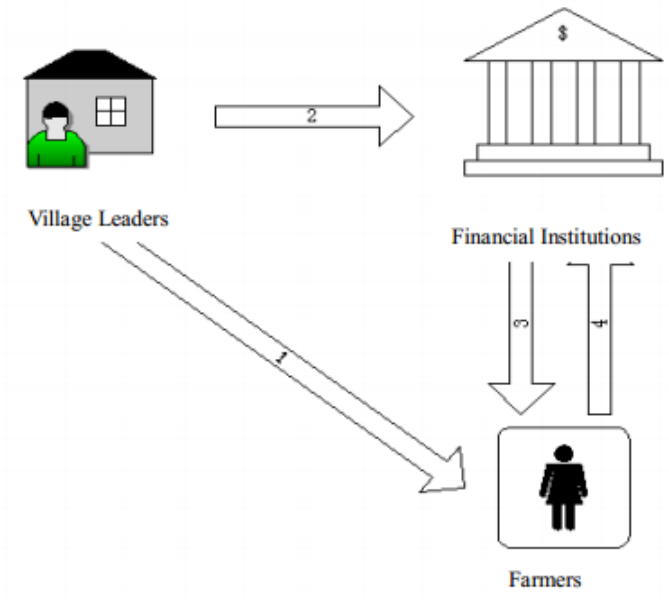


Figure 7: The main relationships in the model of microcredit for rural household, Xi et al. (2009)

1.4.5 The model of co-guarantee loans of rural household

According to this model, rural households form a mutual guarantee group, which share joint liabilities, and receive loans from financial institutions. In order to reduce the lending risk, there are some conditions for the group:

- The group must be composed voluntarily
- There must be at least one leader in the group, having prestige, the ability of organization and coordination, and sense of responsibility
- Each rural household can be part of only one group, and their members cannot co-guarantee for each other
- The members of the group need to have a deposit account in financial institutions
- The credit of more than three households must be assessed by financial institutions

As Figure 8 illustrates, the main steps of the model are as follows (dotted line means that it might not happen):

(1) Women Leagues or Agriculture Associations provide co-guarantee loans to rural households, creating connections among them

(2) Women Leagues or Agriculture Associations provide credit information to Financial Institutions

(3) Financial Institutions deliver co-guarantee loans to rural households

(4) Rural households pay back principal and interest to Financial Institutions

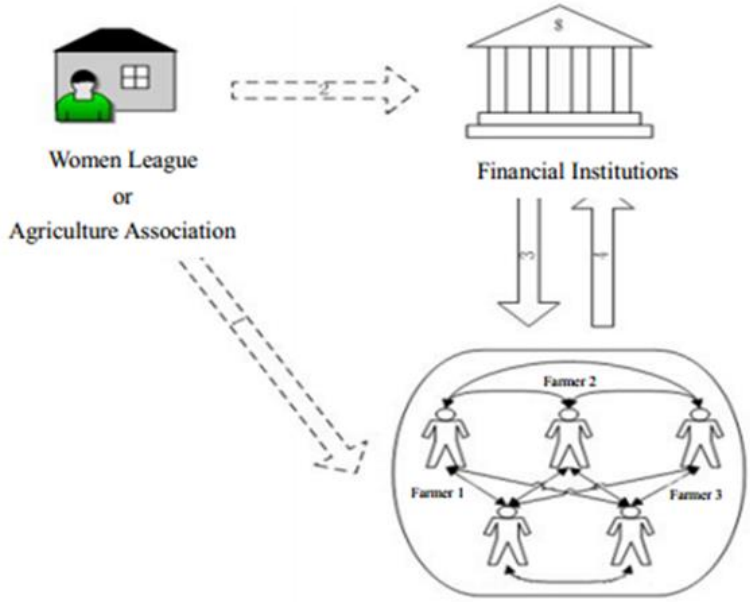


Figure 8: The main relationships of the model of co-guarantee loans of rural household, Xi et al. (2009)

As for the first model, collateral is not needed, nevertheless, financial institutions face a lower risk than in the previous model and for rural households is easier to obtain a loan. Indeed, rural households decide to bear the risk and the potential cost of guaranteeing others in the mutual guarantee group only if they believe others' credit position is good. Hence, this model is based on social capital, since reputation and trust are crucial. In addition, rural households can pay back the principal and interest in a more flexible way than in the first model, i.e. they can repay the principal in one time or in several times and repay the interest monthly, quarterly or yearly.

1.4.6 The model of innovative mortgage loans

According to this model, financial institutions allow rural households to offer their economic resources such as forest tenure, land tenure, and animals as collateral. Thus, thanks to this model, the rural low-income group can have access to credit.

Xi et al. (2009) focused on forest tenure since it is the most common mortgage in the model of innovative mortgage loans. The Forestry Station is the entity responsible for verification, registration, monitoring and disposal of the forest tenure.

As shown in Figure 9, the main steps of the model are:

(1) Rural households go to the Forestry Station to apply for the forest tenure mortgage loans, which in turn issue audit opinion

(2) Rural households submit the application materials for forest tenure mortgage loan to Financial Institutions, which investigate the credit position of the applier

(3) Loan officer and rural households complete formalities in Forestry Station

(4) Financial Institutions deliver loans to rural households

(5) Rural households pay back principal and interest to Financial Institutions

(6) Rural households complete termination formality in Forestry Station after the payment

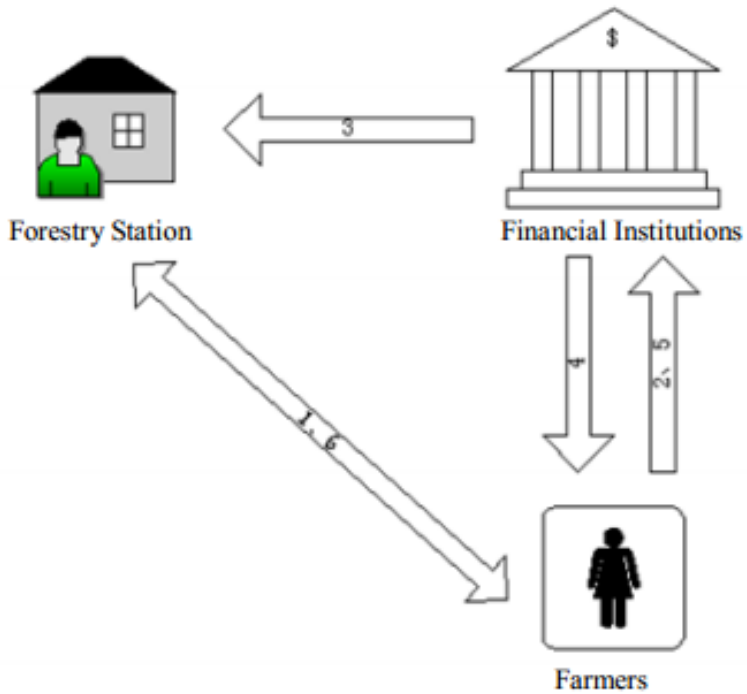


Figure 9: The main relationships of the model of innovative mortgage loans, Xi et al. (2009)

If the rural household defaults, the financial institution sells the guarantied forest tenure and gets the money corresponding to the principal and interest. If instead rural households repay the principal and interest under the contract, there is the cancellation of the forest tenure as mortgage in the Forestry Station.
Thus, in this model the risk of financial institutions greatly decreases.

1.4.7 The model of third-party involvement loans

According to this model, there is a third party entity which guarantees the loans taken by rural households. The most common third-party is the agricultural company, using the resources of BOP (Bottom of the Pyramid).
Many Chinese companies outsource phases of production to the farmers by selling seeds or animals to them and buying their agricultural output at a pre-established price. Moreover, enterprises provide technical assistance and control management to rural households, and thus increase their income by avoiding many problems of traditional production, such as price fluctuations, sudden disasters, low quality of products and lack of sales channel.
Nevertheless, rural households cannot participate in the outsourcing process if they have no access to credit; thus agricultural companies enter microfinancial businesses, in order to help farmers to get loans.
In order to clarify how this model works, Xi et al. (2009) considered Suhai Group Co, the biggest chicken enterprise in Shanxi Province, which is the major chicken provider for fast food restaurants. In order to increase production and then meet the needs of markets, Suhai wanted to outsource chicken to rural households. However, as Yongji Rural Credit Cooperation Association Society highlighted, on one side the company was short of chicken and on the other side rural households were short of initial capital. Therefore, Yongji decided to lend money to rural households under the company's guarantee.

As Figure 10 highlights, the main steps of the model are:

(1) Financial Institutions provide loans to rural households and transfer them to companies
(2) Companies offer technical training, seeding and fodder to rural households

(3) Companies buy products from rural households

(4) Companies pay back principal and interest to Financial Institutions

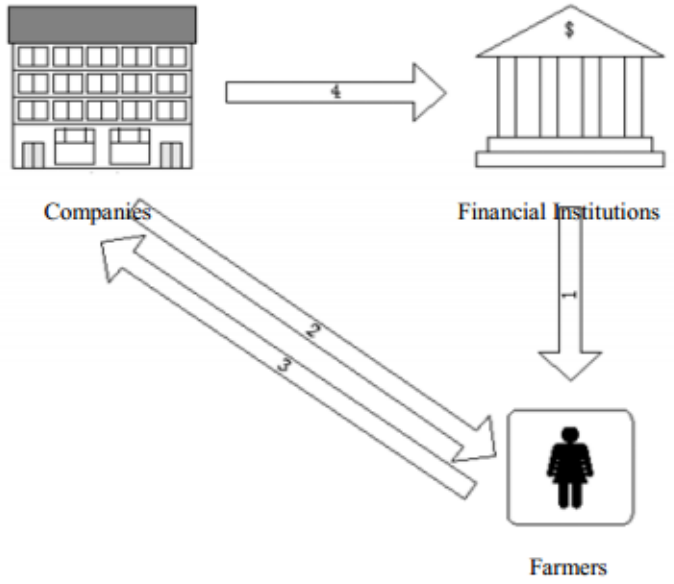


Figure 10: The main relationships of the model of third-party involvement loans, Xi et al. (2009)

This model is considered as a financial innovation in rural areas since it allows farmers without mortgage to get loans in an efficient way. Rural households can improve their living condition since they receive a certain income in the future given that the company buys the agricultural output at a certain price. In addition, the company can purchase the output at a convenient price and financial institutions face low risk; hence they both combine their economic goals with their social responsibilities.

1.4.8 A comparison between microcredit models

According to Xi et al. (2009), the model of microfinance for rural household is the most widespread in rural China and also the most affordable from the farmer's perspective. Indeed, rural households can obtain a loan only on the basis of the credit rating requirement, and principal and interest repayment is flexible. Nevertheless, even if financial institutions collect information from the village leaders, in the absence of mortgage, the lending risk is high, thus the credit amount is relatively low.

The model of co-guarantee loans for rural household is the second most frequent model in rural China.

As for the first model, the term of the loans as well as principal and interest repayment is flexible. In addition, the risk of lending is lower due to the presence of the mutual

guarantee group, thus the credit amount is higher than the previous model. However, given that rural households have to repay others' loans in case they do not do it, the cost of borrowing is higher.

The model of innovative mortgage loans is characterized by restrictive requirements, in particular, farmers are asked to offer their economic resources as mortgage. The amount of credit is usually high but the term of the loans as well as principal and interest repayment is very rigid, thus a small number of farmers are selected. The cooperation with the forestry station is essential for this model.

The model of third-party involvement loans is highly affordable and applicable, indeed financial institutions are informed about the specific use of the loans and establish a loan program for farmers. Obviously, the contact with the third-party company is crucial in this model.

The main characteristics of these four microfinance models are summarized in Figure 11.

The type of model	Operational requirements	Amount of credit	Affordability	Applicability	Requirements for social capital
The model of microcredit for rural household	Low	Small	Better	Better	More contact with village officers
The model of co-guarantee loans	Low	Larger	Good	Better	Less contact with Women League or Agriculture Associations
The model of innovative mortgage loans	High	Larger	Better	Good	More contact with Forestry Station
The model of third-party involvement loans	Highest	Larger	Excellent	Excellent	Closely linked with company

Figure 51: Comparison between four microfinance models, Xi et al. (2009)

1.4.9 Principles of sustainable microfinance in rural China

On the basis of the analysis of these four models, Xi et al. (2009) identify some key principles that should be implemented by financial institutions in the microfinance sector in rural China.

(i) **Affordability.** Financial institutions should ensure the affordability of microfinance products for rural households. According to CGAP (2004), in fact, it is of utter importance that the poor can have access to credit continually. For rural households, the interest rate represents the biggest part of the cost of a loan. In China, microfinance interest rate is about 10%, which is lower than the average level in other countries (in Grameen Bank, it is about 20%). Financial Institutions aim at maximizing profits of microfinance business, mainly driven by interests. Instead, they should reduce the risk through financial innovation and thus decrease the interest rate increasing the affordability of the poor in China.

(ii) **Applicability.** Financial institutions should facilitate the applicability of microfinance products. In particular, they should consider the situation of rural households, which usually have no formal credit history and thus little capital accumulation, low income, mostly coming from agriculture, and lack official certification, so that their economic cannot be used as collateral. For instance, the model of microcredit for rural household does not require any collateral nor formal credit history, and the maturity is one year, given that loans are used in agricultural production. In the model of co-guarantee loans for rural household, social capital is accepted as virtual collateral. In the model of innovative mortgage loans, economic resources of rural households can be used as mortgage. Lastly, in the third-party involvement loans, after evaluating the economic resources of rural households, the third-party entity provides a guarantee for their loans.

(iii) **Social capital.** By exploiting social capital correctly, financial institutions can reduce transaction costs as well as the risk coming from information asymmetry and offer more applicable and affordable microfinance services. For instance, in the model of microcredit for rural household, the local government supports financial institutions in spreading information about microcredit and evaluates the credit rating of farmers. In the model of co-guarantee loans for rural household, the local government help farmers to create mutual guarantee groups. In the model of innovative mortgage loans, financial institutions are closely related to the forestry

station. Lastly, in the model of third-party involvement loans, financial institutions cooperate with agricultural companies, promoting microfinance.

1.4.10 Model selection strategy for financial institutions in rural China

On the basis of the four microfinance models and the principles to conduct microfinance businesses in rural China previously mentioned, Xi et al. (2009) illustrate a model selection strategy for financial institutions in order to enter the BOP market in rural China, making profits and improving the living conditions of the poor at the same time.

Financial institutions can be divided into two main types depending on whether they own local credit information. On one side, there are financial institutions that have been operating in rural areas for a long time and thus own local credit information and cooperate with local government. On the other side, there are financial institutions that are just entering into the market in rural areas, and thus have little social capital and local credit information.

The first type of financial institutions can adopt all models to enter into the market in rural China. They can use the first model if they are able to evaluate the credit rating of farmers and obtain information from village leaders. If instead they want to offer larger amounts of credit they should adopt the other three models. The model of third-party involvement loans may be particularly suited if there are agricultural companies closely linked with rural households.

The second type of financial institutions can adopt the model of co-guarantee. In fact, even if financial institutions do not have assistance from the local government and do not own information about the credit history of farmers, they know that members of the mutual guarantee group decide to bear the risk and cost of guaranteeing each other only if the rural household has good credit.

Alternatively, this group of financial institutions can also adopt the model of innovative mortgage loans, given that farmers are supposed to provide effective and qualified mortgage.

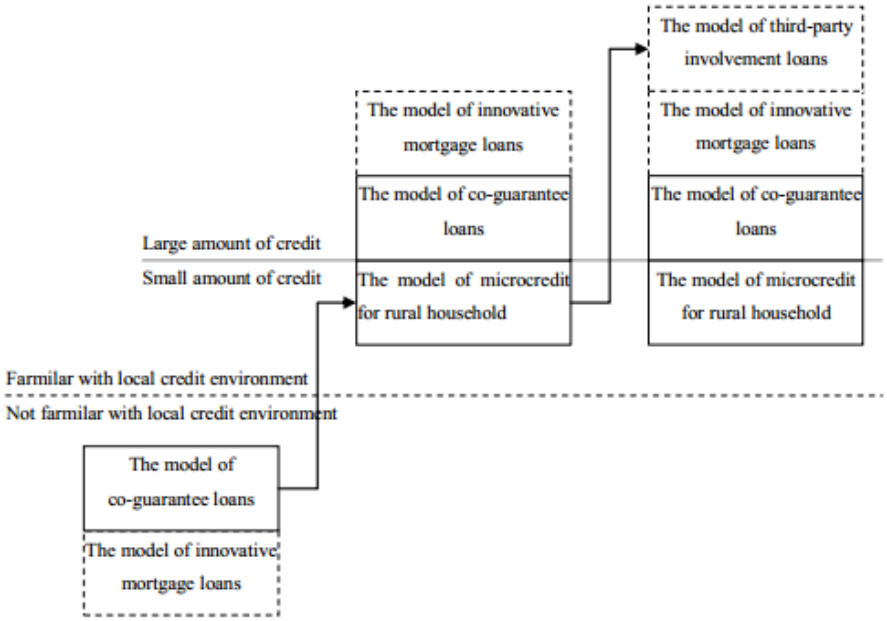


Figure 16: The model selection strategy for financial institutions in rural China, Xi et al. (2009)

1.5 THE ROLE OF MICRO, SMALL AND MEDIUM-SIZED ENTERPRISES

Microcredit has a significant impact on the development of micro, small and medium-sized enterprises (MSMEs), since it helps poor people starting their own business. Therefore, in this section, we are going to discuss the role played by MSMEs.

The contribution of MSMEs to economic growth is widely recognized. As Leutkenhorst (2004) point out, in many developing countries like India, MSMEs are crucial for employment generation since they usually use more labour intensive methods of production than big enterprises. In countries characterized by high income inequality and non-uniform industrial growth, fostering employment leads to a more equal income distribution. -

Moreover, they also provide opportunities to foster entrepreneurship and support the development of productive capacities and create linkages with the big enterprises through which strong economic systems are established.

As some authors argue (Jenkins, 2006; Tilley, 2000), MSMEs have peculiar features which make them completely different from big corporations. Spence and Painter-Morland (2014) highlight the following unique characteristics of MSMEs:

- They have smaller size and fewer resources than big enterprises (Beekman & Robinson, 2004).
- The roles of management and ownership are generally not separated (Richbell et al., 2006).
- Multitask positions within the microenterprise are common.
- Management training does not always satisfy the microenterprise's real needs (Emiliani, 2000; Park & Krishnan, 2001).
- The main objective is solving day-to-day problems.
- Informal interpersonal relations and communication are crucial.
- They are connected with their environment or communities in which they operate as benefactors or local activists.
- They are subject to market dynamics dictated by big corporations, which very often they supply to (Spence, 1999; Spence & Lozano, 2000; Enderle, 2004).

1.5.1 Ethics and Corporate Social Responsibility

In the past, CSR in MSMEs has been overshadowed by CSR in big organisations (Moore & Spence, 2006; Spence & Rutherford, 2003), while more recently, several studies have been focusing on CRS in MSMEs (Vyakarnam et al., 1997; Spence & Lozano, 2000; Murillo & Lozano, 2006). Indeed, as Spence and Painter-Morland (2014) highlight, even if each microenterprise does not have a significant individual influence like big enterprises, their cumulative social and environmental impacts may be extremely important. Therefore, trying to understand the mechanisms of corporate social responsibility (CSR) and ethics in MSMEs in developing countries is crucial.

When managing a business, ethics establishes "what ought to be done or what ought not to be done" (Kuratko et al., 1997). In particular, according to Haron et al. (2015), "ethics refers to standards of behaviour that guide human action in many situations, defining which acts are right and which wrong". The Institute of Business Ethics further defines business ethics as the application of ethical values, such as fairness, honesty, openness, and integrity to business conduct. Entrepreneurs should recognise the importance of these values in order to apply them in business contexts (Hunt and Vitell, 1986).

Corporate Social Responsibility (CSR) can be defined as "open and transparent business practices that are based on ethical values and respect for the community, employees, the environment, shareholders and other stakeholders. It is designed to deliver sustainable value to society at large" (Malaysia, 2013). According to Freeman (1984), there exist six main stakeholders in each firm: the environment, the community, the employees, the customers, the suppliers and the shareholders. As Amran and Nejati (2012) point out, CSR can be measured in six dimensions:

(i) Responsibility to the environment
(ii) Responsibility to the community
(iii) Responsibility to the employees
(iv) Responsibility to the customers
(v) Responsibility to the suppliers
(vi) Responsibility to the shareholders

As highlighted by Haron et al. (2015), these responsibilities are related to the following objectives:

(i) Ensuring the environmental sustainability of the business
(ii) Contributing to the welfare of society
(iii) Pursuing the happiness of the employees
(iv) Providing high quality and innovative goods and services at fair prices, in order to achieve customer satisfaction
(v) Building good relations with suppliers, and promoting the expansion of the business
(vi) Building good relations with shareholders, and promoting the longevity of the company

1.5.2 Micro, Small and Medium-Sized Enterprises in China

The development of MSMEs in China is getting increasing attention worldwide. They always played a major role; nowadays MSMEs still represent 99% of all enterprises, they account for about 60% of national GDP, 66% of innovations (e.g. patents) and they absorb over 80% of the total labour force, as shown by Figure 7.

However, MSMEs can hardly have access to formal banking loans for several reasons, such as lack of reliable information, lack of traditional collateral, and weak formal contract enforcement. From Figure 8, we can see that, according to 2010 data, China has the highest percentage of financially unserved firms (i.e., those that would like to have a loan but do not have one), compared to a set of 52 economies. Moreover, Figure 8 highlights that MSMEs density is on average lower in countries where the percentage of financially unserved firms is bigger.

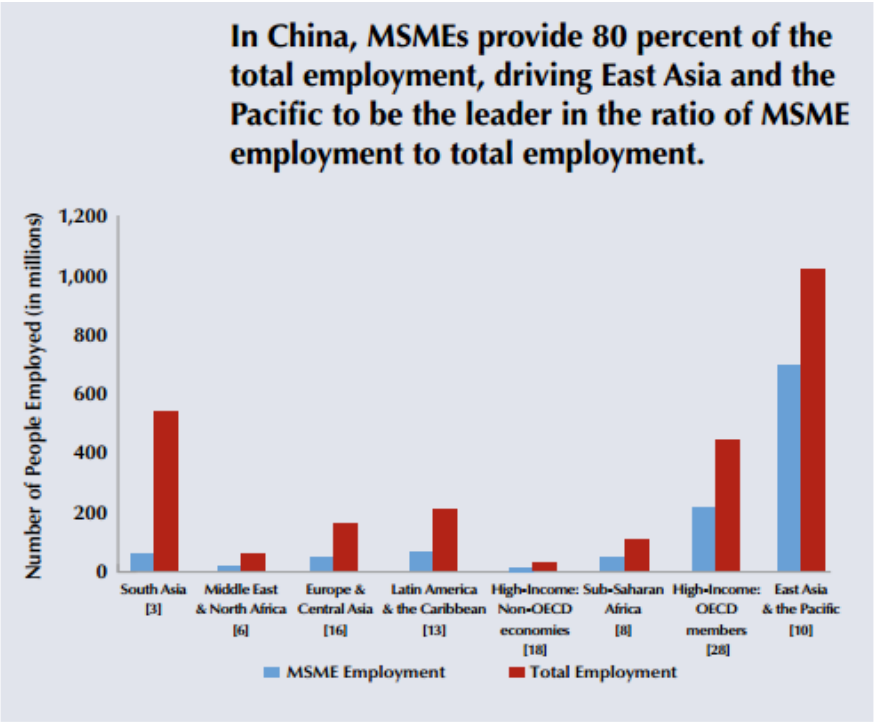


Figure 7: MSMEs employment compared to total employment, Kushnir at al., (2010)

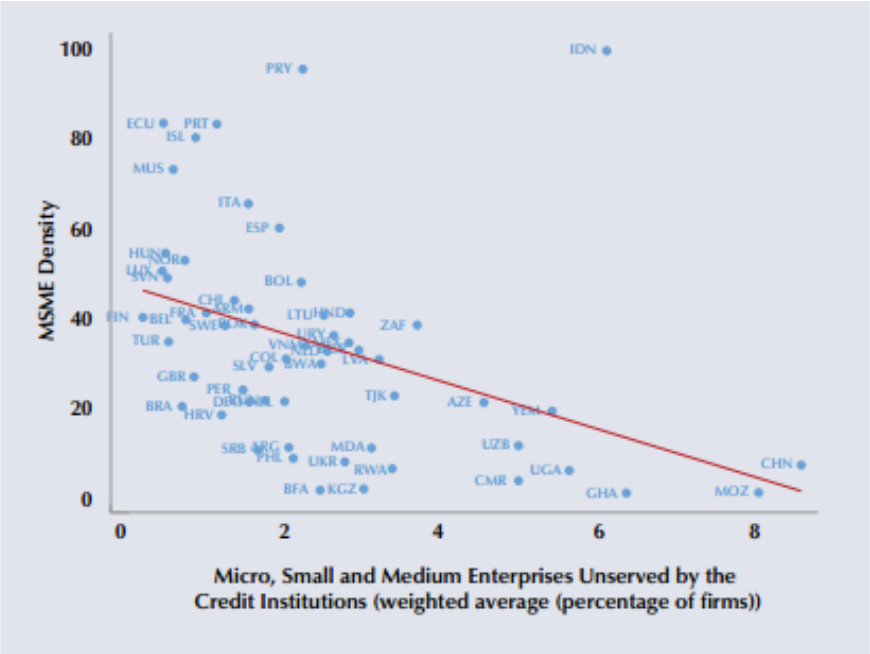


Figure 8: MSMEs Density and MSMEs Unserved by the Credit Institutions, Kushnir at al., (2010)

Thus, the development of microcredit is crucial to respond to the challenges of the lack of formal finance for MSMEs in China.

1.6 Why Is It Important to Target Women?

According to to Cheston and Kuhn (2002) and a report of the NGO, the Microcredit Summit Campaign, published in 2011, about 74% of microcredit borrowers in the world are women. This is even truer in developing countries, such as Bangladesh (97%), or Vietnam. Microcredit helps women to prosper in these countries, essentially dominated by men. Quoting Juan Somavia, the International Labour Office Director-General:

> Microcredit plays a critical role in empowering women, helps deliver newfound respect, independence, and participation for women in their communities and in their households

Mayoux (2001) distinguishes three paradigms on microcredit and gender:

(i) **Financial self-sustainability paradigm.** According to this view, it is important to target women because of efficiency considerations: women have higher repayment rates than men and their economic activity strongly contributes to economic growth. The underlying assumption of this paradigm is that increasing women's access to microcredit will automatically result in economic empowerment which can be defined as "expansion of individual choice and capacities for self-reliance": Thus, no other complementary interventions are needed.

(ii) **Poverty alleviation paradigm.** According to this view, it is important to target women because female poverty is higher than male poverty (indeed, 70 percent of the world's poor are women) and women are responsible for the household well-being. The underlying assumption of this paradigm is that "women's empowerment, household level poverty alleviation and community development are inherently synergistic; increased well-being and group formation will automatically enable women to empower themselves". Thus, in this context, the definition of empowerment coincides with a notion of "increased wellbeing, community development and self-sufficiency".

(iii) **Feminist empowerment paradigm**. According to this view, it is important to target women because it allows promoting gender equality and human rights. The underlying assumption of this approach is that "women's empowerment requires fundamental change in the macro-level development agenda as well as explicit support for women to challenge gender subordination at the micro-level". Thus, in this setting, the definition of empowerment corresponds to the idea of "transformation of power relations throughout society".

Thus, Mayoux (2001) identifies three dimensions of women empowerment induced by access to credit, which are depicted in Figure 9:

(i) **Economic empowerment.** Women gain a more important economic role in taking decisions concerning savings and credit.

(ii) **Increased well-being.** Women gain a more important role in taking economic decisions concerning the well-being of themselves and their children. In particular, they will tend to promote nutrition, health and literacy within their

households, whereas men may employ part of their resources in unhelpful (and sometimes even harmful) activities.

(iii) **Social and political empowerment.** It can be defined as a combination of increased economic activity, control over income, better women's skills, mobility, access to information and to expanded networks.

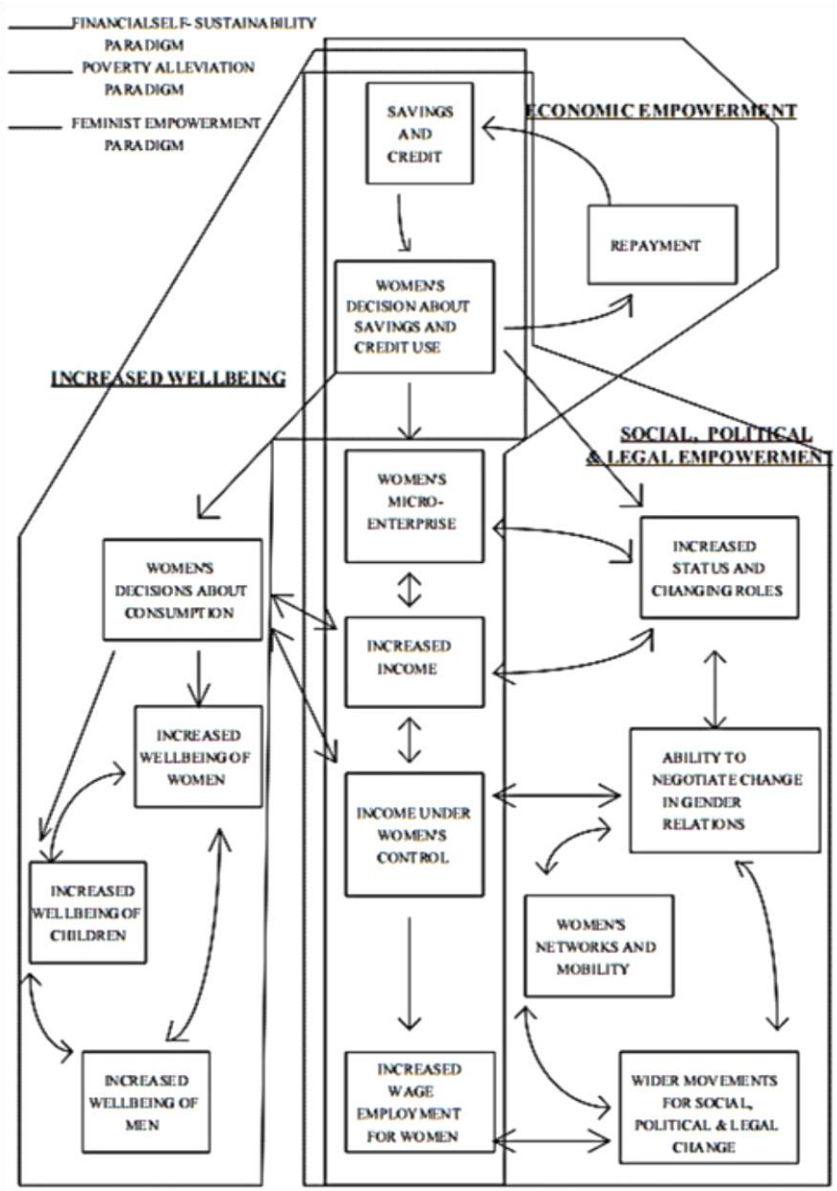


Figure 9: Comparing the three paradigms, Mayoux (2001)

Some key statistics provide overwhelming evidence that empowering women in developing countries can accelerate economic and social development:

- Women invest up to 90% of their income back into their families and communities, while men invest only 30% to 40% of their income (OECD, 2008).
- In many low and middle-income countries, women cultivate up to 80% of the food (Food and Agricultural Organization, 2009).
- In Sub-Saharan Africa, if women had the same access to basic resources (such as land, seed and fertiliser) as men, the agricultural productivity could increase by up to 20% (OECD, 2008).
- In India, an increase by 10% of the ratio of women to men workers could result in an increase by 8% of the Gross Domestic Product (GDP) (OECD, 2008).
- In some African countries, children of women with five years of primary school education have a 40% higher probability of surviving beyond the age of five (OECD, 2008).
- In thirteen out of fifteen Latin American countries, children of employed women have a 5% higher education performance than other (Inter-American Development Bank, 2006).

Thus, as the GSMA Development Fund and the Cherie Blair Foundation for Women (2011) point out, women are fundamental socio-economic change agents.

1.6.1 Women's Networks

Microcredit allows poor women to be part of an expanded network of people. There is evidence that connectivity among women leads to important benefits. For instance, mobile technology, which allows women to be better connected, represents a powerful life enhancing and income generating tool, a driver of economic growth in developing countries. The GSMA Development Fund (2011) supports this idea by stating that:

> People at the base of the economic pyramid need to be empowered with the right tools to find employment and build businesses that will enable them to eventually escape poverty. Among the most important of these tools is a mobile phone.

The following statistics highlight the positive relationship between mobile technology and economic and business development:

- If mobile phone penetration rates increase by 10%, then GDP of low and middle-income countries increases by 1.2% (Deloitte, 2007).
- In India, the mobile industry has generated 3.6 million jobs in and it is expected to create a million more jobs each year (Ovum, 2006).
- 62% of businesses in South Africa and 59% in Egypt ascribe higher profits to the

However, the report *Women & Mobile: A global opportunity*, conducted by the GSMA Development Fund (2011), outlines that the mobile phone gender gap in low and middle-income countries is significant: there are 300 million fewer female subscribers than male subscribers and a woman is 21% less likely than a man to own a mobile phone. According to the report, based on in-depth interviews, third-party data and survey of more than 2000 women in four low and middle-income countries (Bolivia, Egypt, India and Kenia), the major factors that influence mobile phone ownership by women in these areas, are:

- Urban location versus rural location: a woman living in an urban area has a 23% higher probability of owning a mobile phone with respect to a woman living in a rural area, ceteris paribus (i.e., when all other factors, such as age, income, education and occupation, are equal). This is mainly due to the delay in receiving mobile phone coverage and to the lower exposure to mobile technology in rural areas, compared to urban ones.

- Income: if the monthly household income increases by US$100, then a woman's likelihood of owning a mobile phone increases by 13%.

- Age: the highest mobile phone ownership rates are among women between 28-36 years of age, while the lowest ones are among women over 50 years old. Moreover, women aged 14-27 years old have the highest rate of borrowing, which indicates that they face some barriers in owning mobile phones.

- Occupation: the highest ownership rates are among working women, especially in professional, technical and administrative fields, but also female business owners and students have relatively high rates.

- Education: mobile phone ownership rates for women with a college degree are over 90%, while they are just over 20% for women with no schooling.

As the report points out, mobile phones can help women strengthen networks outside of their families, so that they can share information and knowledge.

For instance, The Women of Uganda Network (WOUGNET), created in 2000 with the aim of exploiting information and communications technology (ICT) to share information among women, began its activity with a programme based on the use of mobile phones to spread information about agriculture among rural women farmers' groups. Thanks to the initiative, women could share ideas with each other and address issues collectively, communicate with local agricultural organisations and extension workers. The project was successful since the groups could earn extra income and one of them grew significantly and started honey production and sunflower cultivation on a large scale.

Therefore, there is compelling evidence that, connecting women leads to many benefits, such as improving women's access to literacy, health, banking, employment and business opportunities and facilitating women's participation in all aspects of public life.

1.6.2 Promoting Gender Equality in China

There is evidence that involving Chinese women in microcredit programmes has a positive impact on gender equality. For instance, in 1999, the Guangxi Women's Federation and the Liuzhou Women's Federation launched a project aiming at spreading microcredit among urban laid-off women, using RMB 800000. Towards the end of March, RMB 5.1 million in microcredit loans were distributed, 2002 women found a job, and positive economic and social benefits were achieved.

Obviously, it has to be said that, as microcredit alone cannot eliminate poverty, "empowerment cannot be assumed to be an automatic outcome of microfinance

programmes" (Mayoux, 2001). Thus, microcredit should be an integral part of other policy interventions aiming at promoting women's empowerment.

1.7 GUANXI NETWORKS IN CHINA

In this section we are going to analyse a concept which is particularly important when dealing with micro, small and medium enterprises in China and thus relevant for our model: Guanxi. A large strand of literature on doing business in China gives recognition to the concept of Guanxi as one of the crucial factors leading business success (Abramson and Ai, 1999; Davies et al., 1995; Lee et al., 2001; Luo, 1997; Tsang, 1998; Yeung and Tung, 1996). Even though it may be considered very similar to the Western business practice of "networking", Guanxi is definitely much more culturally rooted (White, 2006).

1.7.1 The Role of Confucianism

Historically, several countries in East Asia have been strongly influenced by the school of ethical, philosophical and religious thought developed from the teachings of the Chinese sage Confucius (551 – 479 B.C.), such as China, Taiwan, Hong Kong, Macau, and Korea. The most important objective in a Confucian society is the pursuit of harmony and social order, "renlum" (Hoiman, 2003). In a complex society of human beings, the social order can be attained through an ordered hierarchy and stable networks of interpersonal relationships, i.e. through Guanxi (Luo, 1997). The five main types of Confucian relationships are: ruler-subject, father-son, brother-brother, husband-wife, and friend-friend (Yeung and Tung, 1996). The first two relationships are given, while the other two are constructed voluntarily. The idea behind Confucianism is that each individual's fulfilment of the obligations of its role is crucial for a smooth functioning of the society.

According to Hwang (1987), there are two main important components in the dynamic of Guanxi, which descend from the harmony principle of Confucianism:

(i) "Renqing" (favour). It indicates an informal social obligation, characterized by a reciprocal exchange of personal favours (Lee et al., 2001). Huang and Harris Bond (2012) distinguish between "renqing", which is an economic or instrumental exchange, and "ganqing", which is a social or expressive exchange.

(ii) "Mianzi" (face). Each individual has to show her face to others and safeguard her prestige (Hwang, 1987). Thus, in order to build a viable Guanxi network mianzi is fundamental (Redding and Ng, 1982). Losing mianzi corresponds to losing social reputation and personal dignity (Zhang and Zhang, 2006).

1.7.2 What Does Guanxi Mean?

It is very difficult to find a perfect translation for the term Guanxi; usually it is translated as "connection", "social networking", "interpersonal relationship", or "personal connection" (Hackley and Dong, 2001). It is composed of two Chinese characters: the first is guān (关), which means "to close", and the second is xì (系), which means "department, group, or organization". Thus, Guanxi can be interpreted as the gate through which an individual can access a group (White, 2006). In other words, Guanxi is a personal relationship based on friendship, satisfaction, trust that is beneficial for the parties involved.

Yang (1993) proposes three main types of Guanxi in China:

(i) "Jia-ren Guanxi", i.e. relationships among family members

(ii) "Shou-ren Guanxi", i.e. relationships with relatives, friends, neighbours, colleagues, classmates, coprovincials, etc

(iii) "Sheng-ren Guanxi", i.e. relationships with acquaintances or strangers

These three types of Guanxi "are governed by different sets of interpersonal rules" (Tsui and Farh, 1997). Thus, as Fock and Woo (1998) highlight, Guanxi plays varying roles depending on the context in which it is used and has many implications in the Chinese society.

According to White (2006), being able to maintain a network is even more important than building a network. Indeed, using the words of Yeung and Tung (1996), Guanxi is "…a gate that can be open or shut, it needs to be propped wide open once opened; otherwise, it can slam shut again." There are four basic strategies to maintain Guanxi network (Yeung and Tung, 1996):

(i) The exchange of gifts or favours. This may be useful at the beginning of the relationship but it is not sufficient to maintain it forever.

(ii) The exchange of information, ideas and feelings. This allows building a relationship on a personal level.

(iii) Interconnectivity. By increasing interconnectivity, interdependence grows and the costs of ending the relationship rise for the two parties involved.

(iv) The cultivation of trust. This is the most important element given that China is a relation-based society and trust plays a crucial role in all aspects of the Chinese society.

These four strategies reflect the fundamental dimensions of Guanxi: instrumentalism, reciprocity, personal relationships, longevity, and trust (Yeung and Tung, 1996).

1.7.3 The Significance of Guanxi

By surveying 2000 Chinese from Shangai (the centre of commercial activities in China) and Qingpu (a rural county outside of Shangai) in 1993, Chu and Ju tried to measure the significance of Guanxi in everyday life. Their results show that:

- 92.4% affirm that Guanxi has a major role in their life
- 84.5% do not trust other people until a relationship is formed
- 71.7% prefer to appeal to their Guanxi networks rather than to normal bureaucratic channels in order to solve problems
- Younger people put more emphasis on Guanxi in their lives than older people

This survey highlights that, despite the evolution of China due to globalization, the values of the traditional Confucian culture still play an important role: there is a perceived need to guarantee trust and maintain harmony, which leads to special importance being placed upon personal relationships. As Murphy (1996) highlights, “nothing ever happens in China without a relationship” due to the high level of innate distrust of the Chinese. Thus, as a Chinese saying points out, the key success factors in conducting a business in China are “tian-shi, di-li, ren-he”, which means “right timing, right place, right people”. Su (2003) underlines that the “right people” are represented by Guanxi networks. “Consequently, to succeed in China, an investor has to identify the

right parties with whom to establish the right connections. Furthermore, these relationships must be nourished and maintained over time" (Yeung, 1996).

The main advantage of Guanxi is that it "improves business efficiency, and is used by the weak and the disadvantaged to protect themselves and to secure business opportunities against competition from outsiders" (Fock, 1998).

Davies et al. (1995) conducted a survey on a sample of 150 Hong Kong executives, illustrating the benefits of Guanxi in China from the viewpoint of an outsider. The results are reported in Figure 1.

	Mean	Score Rank	% Rating 6	% Rating 1
Sources of Information				
Market Trends	4.14	10	16.0	3.30
Government Policies	4.53	3	24.7	2.00
Import Regulations	4.56	2	27.3	4.70
Business Opportunities	4.51	5	28.7	2.70
Sources of Resources				
Import License Applications	4.38	8	30.0	8.70
Approval of Advertisement	3.07	15	2.00	18.0
Approval of Applications to Provincials	4.47	6	30.0	4.00
Approval of Applications to Cent. Gov.	4.39	7	28.7	6.70
Recruitment of Labor	3.25	14	2.70	14.7
Securing Land for Joint Ventures	3.60	12	12.0	14.0
Securing Electricity for Joint Ventures	3.81	11	20.7	14.0
Securing Raw Materials for J. Ventures	3.45	13	11.3	20.0
Other Areas				
Building Corporate Reputation	4.30	9	22.0	4.00
Smooth Transportation Agreements	4.53	3	24.7	2.00
Smooth Collection of Payment	4.70	1	39.3	4.70

Figure 10: Perceived Benefits of Guanxi (6 is the highest possible rating, and 1 is the lowest), Davies et al. (1995)

1.7.4 "Good" and "Bad" Guanxi

Roughly, we can distinguish three fields in the Guanxi literature:

- Interpersonal or person-to-person (P-P) Guanxi
- Inter-firm or business-to-business (B-B) Guanxi
- Guanxi between a firm and a governmental body or (B-G) Guanxi

Both scholars who focused on the first type of Guanxi (e.g. Chen and Peng, 2008; Farh et al., 1998; Tsui and Farh, 1997) and scholars who focused on the second type (e.g. Luo, 2007) cast a positive view on Guanxi.

Scholars who focused on the third type, instead, cast a negative view on Guanxi, taking an ethical perspective (Dunfee and Warren, 2001; Fan, 2002; Luo, 2008; Su and Littlefield, 2001). Basically, negative judgements on Guanxi arise when the lower level dyadic Guanxi is connected to the superordinate level of a higher entity (e.g. Chen and Chen, 2009; Warren et al., 2004).

Thus, following the approach of Huang and Harris Bond (2012), we can distinguish between "good" Guanxi and "bad" Guanxi.

1.7.4.1 Defining "Good" Guanxi

Research on "good" Guanxi typically refers to social capital and social exchange theories (Bian, 1997; Law et al., 2000; Xiao and Tsui, 2007). Social capital theory (Coleman, 1990) is useful to understand the reasons of Guanxi development and its importance for the success of individuals and enterprises, while social exchange theory (Blau, 1964) is useful to understand the mechanisms through which Guanxi is built and maintained. Essentially, social capital theory considers that relationships are a resource for social action (Nahapiet and Ghoshal, 1998). In order to conceptualize social capital, three main approaches have been put forward (Huang and Harris Bond, 2012):

(i) The weak tie approach (Granovetter, 1973)
(ii) The structural hole approach (Burt, 1992)
(iii) The social resource approach (e.g. Lin et al., 1981)

Approach **(ii)** will be analysed in Chapter 2, after introducing some concepts of Network analysis, given its importance for our model.

According to Huang and Harris Bond (2012), Guanxi can be viewed as "a special type of social network in the Chinese context which can be manifested in the form of a weak tie (a distant Guanxi), a structural hole (an intermediary), or social resource (properties associated with the Guanxi partner)".

Social exchange theory, instead, focuses on social exchanges, which involve both tangible and intangible resources (Foa and Foa, 1974) over an indeterminate period, and are based on trust and commitment (Emerson, 1981).

The strand of literature which takes this perspective views P-P and B-B Guanxi in a positive way and defines it as "a lubricant for solving conflict, for effective communication, better understanding, greater trust, more collaboration, reducing

transaction costs or increasing efficiency" (Huang and Harris Bond, 2012). Thus, Guanxi serves as a social capital or resource useful to negotiate benefits for the individual and her related parties (Bian, 1997; Su and Littlefield, 2001). According to this view, Guanxi is a special relationship between two persons (Alston, 1989) or a particularistic tie based on common attributes and background (Jacobs, 1982; Tsui and Farh, 1997) or a connection characterized by frequent contact between people (Bian, 1997).

P-P and B-B Guanxi are simply "processes" through which people and firms can interact (Fan, 2002), have reciprocal exchanges (Hwang, 1987), or a continuous exchange of favours (Pye, 1982). Chen and Chen (2004) consider Guanxi as:

An informal, particularistic and personal connection between two individuals who are bounded by an implicit psychological contract to follow the social norms of Guanxi, such as maintaining a long-term relationship, mutual commitment, loyalty and obligation.

Research on interpersonal Guanxi found the following results:

- Guanxi facilitates deal-making (Blackman, 1997).
- Guanxi assists job hunting (Bian and Ang, 1997; Giles et al., 2006; Zhang and Li, 2003; Zhang, 2006). For instance, Zhang (2006) highlights how Chinese women leaving in rural areas rely on their Guanxi networks in order to reduce risks and costs related to migration and to find an employment in urban areas.
- Guanxi increases the likelihood of obtaining higher performance evaluations or promotions (Law et al., 2000). Indeed, supervisors are more likely to reward individuals with whom they have good rather than poor Guanxi (Law et al., 2000).
- Guanxi can enhance the individual's performance and her career achievement (Wong and Slater, 2002; Xiao and Tsui, 2007). In fact, subordinates have higher trust in supervisors with whom they have good rather than poor Guanxi, and put more effort in their activity.

Moreover, there are two main features which characterize the nature of P-P Guanxi (Hwang, 1987):

- Expressiveness. For instance, familial Guanxi is purely expressive.

- Instrumentality. For instance, a one-time transaction between buyer and seller is purely instrumental.

Within organizations, Guanxi has a mixed nature (Chua et al., 2009; Chen et al., 2009; Chen and Peng, 2008; Tsui and Farh, 1997). For instance, in the workplace, co-worker Guanxi is made by both work-related activities, i.e. instrumental, and non-work-related activities, i.e. expressive or affective (Chen and Peng, 2008). In general, Guanxi in the Chinese society cannot be instrumental only, given that the Chinese collectivism considers the family as a model for relationships and expand its values, beliefs and behavioural rules to any other contexts (Bond and Hwang, 1986).

As far as inter-firm Guanxi is concerned, research highlights several benefits (e.g. Luo, 1997; Luo and Chen, 1997; Luo et al., 2002; Park and Luo, 2001; Peng and Luo, 2000; Tung and Worm, 2001).

- Guanxi provides a competitive edge in terms of market performance (Luo, 1997)
- Guanxi has a positive impact on sales growth (Luo et al., 2002)
- Guanxi benefits enterprises' efficiency and market expansion (Luo and Chen, 1997)

In the next paragraph, we are going to analyse in more detail what are the effects of B-B Guanxi on the process of joint new product development. They will be significant for the development of our model.

1.7.4.1.1 The role of B-B Guanxi in the process of NPD

According to Fang (2008), there is empirical evidence that joint new product development (NPD) between enterprises can reduce development times and lead to highly innovative products.

However, Zhang and Zhang (2006) highlight that, in Asia, the majority of enterprises think that Guanxi plays a more important role than impersonal inter-enterprise relationships in increasing enterprise performance. Following this approach, Cui et al. (2013) point out that inter-organizational cooperation cannot take place without interpersonal contact and communications. They conducted a survey on 500 manufacturing enterprises in central China, 354 of which were involved in a joint NPD. Their results challenge the view of the resource-based theory, which argues that the

fundamental factors of success of an enterprise are represented by some unique capabilities in technologies and marketing (Barney, 1991).

Indeed, Cui et al. (2013) highlight how, in the Chinese business context, personal Guanxi is crucial in two respects:

(i) Guanxi allows accessing to and sharing informal information on new products. This is particularly important given that, in the Chinese market, a lot of information is inaccessible and thus enterprises have to rely on personal connections (Sheng et al., 2011). In particular, the greater is managerial Guanxi, the more likely is that the following types of information, which facilitate new product innovativeness, emerge:

a) Information outside the enterprise, such as findings from upstream enterprises (concerned with the search for raw materials) or market survey results from downstream enterprises (concerned with the transformation of raw materials into a finished product that can be sold to customers).

b) Tacit knowledge and process information which is hardly transferred through impersonal contacts (Madhavan and Grover, 1998).

c) Confidential information on the strategies and risks of NPD (Slater and Narver, 2000).

(ii) Guanxi can foster adaptation and cooperation among enterprises in immature institutional environments (Xin and Pearce, 1996).

Thus, Cui et al. (2013) analysed the impact of managerial Guanxi (i.e. Guanxi between managers in partner enterprises) on the success of NPD through the mechanisms of information sharing and cooperative mobilization. In accordance with Fang (2008) and Griffin (1997), Cui et al. (2013) focused on the two main indicators of the success of NPD in a context of joint NPD:

(1) The speed with which firms create and diffuse products in the market

(2) The innovativeness of products

They showed that the effect of managerial Guanxi depends on the type of inter-firm relationship, precisely on the levels of transaction specific investments (hereafter, TSIs) and relationship commitment (hereafter, RC).

The conceptual model of Cui et al. (2013) is illustrated in Figure 2.

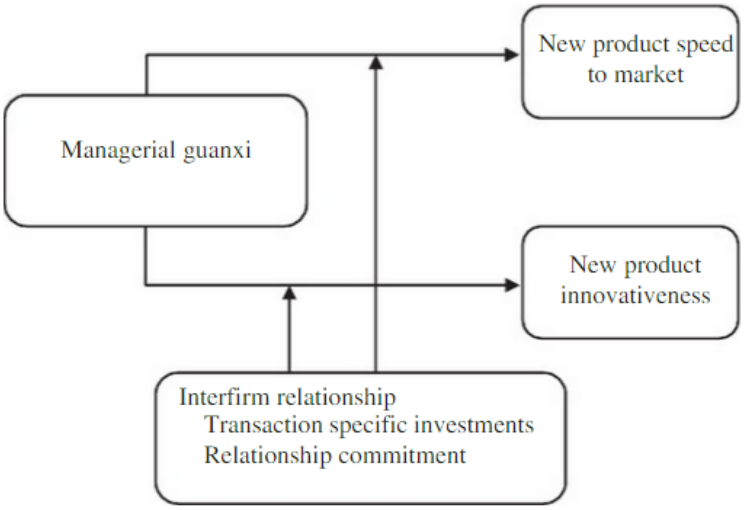


Figure 11: Effects of Managerial Guanxi on joint NPD, Cui et al. (2013)

As far as **(1)** is concerned, referring to Cui et al. (2013), managerial Guanxi has a positive effect on the speed to market of new products. In fact, two mechanisms may take place:

a) Guanxi can encourage people outside the enterprise to provide information, material resources and workforce in order to support NPD in exchange for favours (Luo, 1997).
b) Guanxi makes tolerance increase and decreases the time necessary for negotiation and coordination among enterprises.

However, TSIs have to be considered in the picture. Enterprises with a high level of TSIs undertake activities together (Heide and John, 1990) and invest a great amount of time, human power, assets, abilities into a relationship (Anderson and Weitz, 1992). According to Palmatier et al. (2007), these firms are more likely to support partners in increasing the speed of the NPD process since they could share the related market benefit, obtaining more profits from the relationship. On the contrary, enterprises with a low level of TSIs have less motivation in preserving a relationship with their partners and are less interested in providing resources and support to the NPD process (Gassenheimer and Manolis, 2001).

Figure 3 illustates the impact of managerial Guanxi on **(1)** when TSIs are taken into account: the impact of managerial Guanxi on new product speed is higher for enterprises with greater TSIs than the ones with low TSIs.

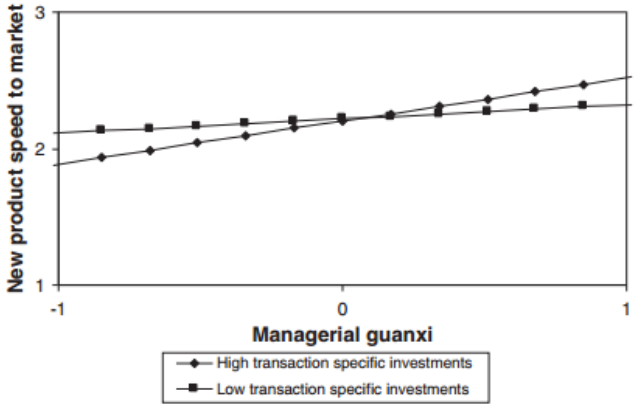


Figure 12: Effect of Managerial Guanxi on New Product Speed to Market, depending on TSIs, Cui et al. (2013)

As far as **(2)** is concerned, when managerial Guanxi is high, new product innovativeness is lower for partner enterprises with great TSIs than those with low TSIs. The reason is that, enterprises with high TSIs, being more subject to the influence of Guanxi, are reluctant to adopt innovative ideas that could prevail on existing specific investments. On the contrary, enterprises with low TSIs are less interested in protecting specific investments (Parkhe, 1993).

Moreover, there is an inverted U-shaped relationship between managerial Guanxi and new product innovativeness for enterprises with high levels of TSIs. Thus, beyond an optimal level, Guanxi can be counterproductive for product innovativeness. The reason is that, at very high levels of managerial Guanxi, there are intense obligations to avoid conflicts, protect face and maintain harmony with existing partners. And, as we learn from creativity research, which underlines that conflicts in viewpoints and problem-solving stimulate creativity (De Dreu, 2006), this may in turn limit enterprises' new product innovativeness.

Figure 4 illustrates the impact of managerial Guanxi on **(2)** when TSIs are taken into account.

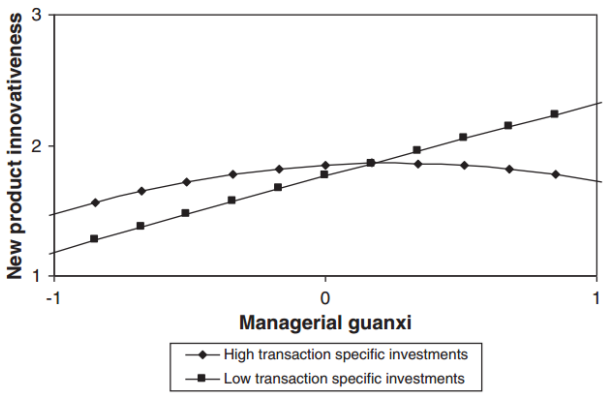


Figure 13: Effects of Managerial Guanxi on New Product Innovativeness, depending on TSIs, Cui et al. (2013)

As previously mentioned, another important aspect to be considered is RC, which is not only instrumental but also emotional (Morgan and Hunt, 1994). In fact, it expresses the desire to maintain a valued relationship (Moorman et al., 1992) and it is animated by common beliefs on behaviours, ideas and goals.

Figure 5 illustrates the impact of managerial Guanxi on **(1)** when RC is taken into account**:** new product speed to market is higher when partner enterprises have high levels of RC rather than low levels.

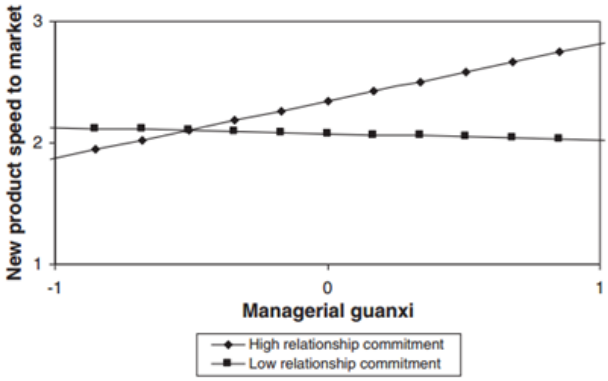


Figure 14: Effect of Managerial Guanxi on New Product Speed to Market, depending on RC, Cui et al. (2013)

Moreover, enterprises with a high level of RC are more likely to have a risk taking behaviour and to promote new product innovativeness with their partners (Abdul-Muhmin, 2005). Thus, tensions caused by different ideas are not considered as threats to

“mianzi” (face) but as a source for innovation (Morgan and Hunt, 1994). Therefore, by considering RC the negative impact of managerial Guanxi on innovativeness is mitigated. In contrast, enterprises with low level of commitment lack mutual project goals with their partners (Moorman et al., 1992), they have a low level of trust (Yilmaz and Kabadayi, 2006), and thus need to spend resources in monitoring their partners.

Figure 6 illustrates the impact on managerial Guanxi on **(2)** when RC is taken into account: when managerial Guanxi is high, new product innovativeness is higher for enterprises with high RC than those with low RC.

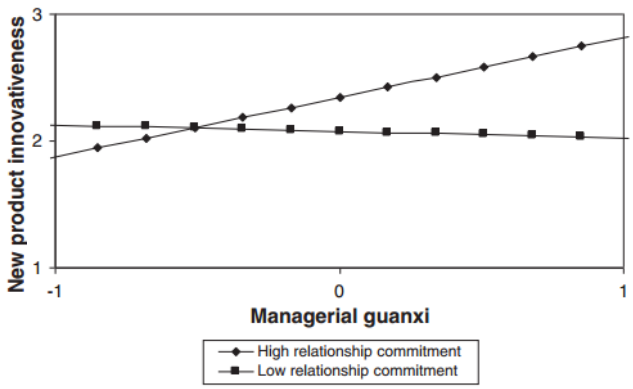


Figure 6: Effect of Managerial Guanxi on New Product Innovativeness, considering RC, Cui et al. (2013)

Therefore, in accordance with Morgan and Hunt’s (1994), Cui et al. (2013) found that high levels of RC across enterprises play the role of a catalyst, making managerial Guanxi move in the proper direction.

These findings have relevant managerial implications for enterprises involved in joint NPD activities in Asia, in particular in China. According to Cui et al. (2013), enterprises should take into account that Guanxi is crucial in joint NPD activities, but may have some negative effects on new product innovativeness, when the level of managerial Guanxi is high. Thus, they should try to reduce the dependence on relationships and preserve independent judgements. Moreover, in order to foster the speed to market, enterprises should choose partners characterized by high levels of RC or specific investments in joint NPD. To foster the production of innovative and creative products, enterprises should involve highly committed enterprises as well, but with low specific investments.

1.7.4.2 Defining "Bad" Guanxi

As Wong and Leung (2001) argue, "there are positive and negative aspects of Guanxi. Viewed positively, Guanxi networks offer an alternative means of facilitating business transactions. Negative aspects include the associated corrupt behaviour, implying costs to national welfare."

Many scholars refer to guanxi as a social dynamic promoting ethical abuse (Ang and Leong, 2000; Dunfee and Warren, 2001; Snell and Tseng, 2002) and assimilate it to corruption and bribery. According to Fan (2002):

B-G Guanxi represents a way to bypass laws and regulations through personal connections with government officials and to obtain special treatment or scarce resources.

According to Su and Littlefield (2001), it is important to distinguish between two different categories of Guanxi prevalent in China:

- Favour-seeking Guanxi. It is culturally rooted and based on tradition.
- Rent-seeking Guanxi. It is institutionally defined, focused on gaining power and personal well-being (Su, 2003). It can be thought as an abuse of the system of Guanxi in a market economy, and as an institutional substitute which fosters opportunistic behaviour (Luo, 2001).

According to White (2006), the study "Is Guanxi orientation bad, ethically speaking? A study of Chinese enterprises" by Chenting Su et al. (2003), highlights that the favor-seeking Guanxi is not unethical and it is part of the "cultural way of doing business". Within the rent-seeking Guanxi, instead, corruption may reach high levels, in particular among state-owned enterprises; B-G Guanxi certainly belongs to this category.

It is important to stress the fact that the amount of Guanxi use is proportional to the size of the enterprises. This means that small enterprises rely more on Guanxi compared to large ones (White, 2006). Moreover, people with more experience and education seem to use less Guanxi (Su, 2003). As we have already said in section 1.5.2, in China, MSMEs can hardly have access to formal banking loans. It is precisely in this context that B-G Guanxi usually takes place and reveals its "bad" nature. In fact, in order to have access to bank credit, MSMEs need for personal connections to facilitate loan

approval, in particular they may rely on credit guarantees offered by governments: these interventions provide opportunities for corruption. Moreover, Guanxi with government officials helps enterprises to access to scarce resources (Luo, 2000), and also to obtain legitimacy and reputation.

Microfinance may be a tool to bridge the gap between the demand for credit and the supply of credit and prevent MSMEs from relying on "bad" Guanxi.

Thus, we think that the concept of Guanxi is related to the topic of microcredit, and therefore relevant for our analysis, for three main reasons:

(i) The importance of P-P Guanxi as informal lending channel may increase when microcredit is absent.

(ii) B-B Guanxi may enhance the performance of enterprises, including those financed by microcredit.

(iii) B-G Guanxi may reveal its dark side when microcredit is absent.

In the model we develop in Chapter 3, we will focus on **(i)** and **(ii)** only. An evolution of the model could include also **(iii),** providing some evidence of whether microcredit can, to some extent, reduce "bad" Guanxi.

Chapter 2

The Theoretical Approach

2.1 AGENT-BASED SIMULATION MODELLING

In this chapter, we discuss the method chosen to analyse microcredit: the first two sections are devoted to Agent-based models (hereafter, ABMs) and network analysis respectively, while the third section discuss the joint use of ABMs and network analysis, focusing on a tool named "recipe", which is crucial in our model.

ABMs represent a new approach capable of modelling human social and organizational behaviour and individual decision-making (Bonabeau, 2001). They are one of the most exciting practical developments in modelling since relational databases were invented (North and Macal, 2007). In the following paragraph, we explain why ABMs are becoming so important, introducing the concept of complexity.

2.1.1 Why Agent-based Models? Looking at Complexity

Why are ABMs so widespread? The answer is because our world is becoming increasingly complex. As Gilbert (2004) points out, while the physical world is full of linear or approximatively linear systems, i.e. such that the properties of the whole are a simple aggregation of the parts, human societies are different. In fact, they are characterized by a multitude of non-linear interactions between their units, involving the transmission of knowledge and materials that influence their behaviour. Therefore, according to Gilbert (2004), human societies are complex systems, meaning that:

> The behaviour of the system as a whole cannot be determined by partitioning it and understanding the behaviour of each of the parts separately, which is the classic strategy of the reductionist physical sciences.

Referring to Boero et al. (2015), in order to understand the concept of complexity, we can quote Anderson (1972), since his paper “More is different” can be considered as a manifesto:

> (p.393) The reductionist hypothesis may still be a topic for controversy among philosophers, but among the great majority of active scientists I think it is accepted without question.
>
> (...) The main fallacy in this kind of thinking is that the reductionist hypothesis does not by any means imply a "constructionist" one: The ability to reduce everything to simple fundamental laws does not imply the ability to start from those laws and reconstruct the universe.
>
> (...) The constructionist hypothesis breaks down when confronted with the twin difficulties of scale and complexity. The behaviour of large and complex aggregates of elementary particles, it turns out, is not to be understood in terms of a simple extrapolation of the properties of a few particles. Instead, at each level of complexity entirely new properties appear, and the understanding of the new behaviours requires research which I think is as fundamental in its nature as any other.

Therefore, according to Anderson, complexity develops when a relevant number of agents, acting as parts of a whole, interact. The same concept is highlighted by Simon (1962):

> (p. 267) Roughly by a complex system I mean one made up of a large number of parts that interact in a non-simple way. In such systems, the whole is more than the sum of the parts, not in an ultimate metaphysical sense, but in the important pragmatic sense that, given the properties of the parts and the laws of their interaction, it is not a trivial matter to infer the properties of the whole.

Similarly, Villani (2006) explains:

> (p.51) Complex systems are systems whose complete characterization involves more than one level of description.

Johnson (2009), who defines Complexity as the "Science of all sciences", summarizes the main aspects that characterize complex systems, as follows:

(i) Complex systems consist of a collection of several interacting objects or "agents". Their interactions take place because of many reasons:

a) Physical closeness among agents
b) Membership in a certain group
c) Sharing public information
d) Sharing private information

These interactions imply the emergence of networks, which have become part of the science of complexity. The relationship between agents and networks will be analysed in section 2.2.

(ii) Agents' behaviour is influenced by memory or feedback effects. In particular, agents may experience two main effects:

a) Path-dependence effect. History matters: past events can influence future events.
b) Knock-on effect. Events happening in a certain location can influence events happening in another location.

(iii) Agents can change their behaviours, on the basis of their history, in order to improve their situation.

(iv) Complex systems are open, i.e. they interact freely with their environment which then affects them.

(v) Complex systems seem to be alive, in the sense that they are dynamic and evolve continuously.

(vi) Complex systems are characterized by unpredictable emergent phenomena, i.e. they are not in equilibrium.

(vii) Emergent phenomena are not supervised by any sort of central controller.

(viii) Complex systems are a mixture of ordered and disordered actions.

Thus, it turns out that it becomes impossible to understand the human society as a whole by analysing the behaviour of each individual within it, one at a time. The behaviour of the society will "emerge" from the interactions between its component units (Gilbert, 2004). Emergent features can be observed also in physical systems, but the main difference with respect to human societies is that people can understand and react to emergent phenomena (Gilbert, 1995). In addition, while physical systems are made of similar or identical units, individuals are completely different from each other in terms of abilities, willingness, needs and culture and also constantly changing, thus societies emerge from a dynamical process.

For these reasons, in order to address complexity, Rosenblueth and Wiener (1945), the founders of cybernetics, stress the necessity to build models. In their paper "*The Role of Models in Science*", we read:

> (p. 317) A material model is the representation of a complex system by a system which is assumed simpler and which is also assumed to have some properties similar to those selected for study in the original complex system.
>
> (...) Material models are useful in the following cases. a) They may assist the scientist in replacing a phenomenon in an unfamiliar field by one in a field in which he is more at home.
>
> (...) b) A material model may enable the carrying out of experiments under more favourable conditions than would be available in the original system.

As Terna (2015) points out, cybernetics represents the root of ABMs and the "material model" cited above corresponds to the artificial artefact of actual systems constructed with an agent-based simulation and compared to the theoretical model.

According to Holt *et al*. (2011), in order to represent material models accurately, it is necessary to take the complexity perspective:

> (Quoting from the RepEc version, p. 5) Since the term complexity has been overused and over hyped, we want to point out that our vision is not of a grand complexity theory that pulls everything together. It is a vision that sees the economy as so complicated that simple analytical models of the aggregate economy—models that can be specified in a set of analytically solvable equations—are not likely to be helpful in understanding many of

> the issues that economists want to address. Thus, the Walrasian neo-classical vision of a set of solvable equations capturing the full interrelationships of the economy that can be used for planning and analysis is not going to work. Instead, we have to go into the trenches, and base our analysis on experimental and empirical data. From there we build up, using whatever analytic tools we have available. This is different from the old vision where economists mostly did the opposite of starting at the top and then built down.

Therefore, in order to manage complexity, it is essential to construct ABMs.

2.1.2 Defining Agent-based Models

Referring to Boero at al. (2015), to provide a comprehensive definition of ABMs, we can quote Axtell and Epstein (2006):

> Compactly, in agent-based computational models a population of data structures representing individual agents is instantiated and permitted to interact. One then looks for systematic regularities, often at the macro-level, to emerge, that is, arise from the local interactions of the agents. The shorthand for this is that macroscopic regularities "grow" from the bottom-up. No equations governing the overall social structure are stipulated in multi-agent computational modelling, thus avoiding any aggregation or misspecification bias. Typically, the only equations present are those used by individual agents for decision-making. Different agents may have different decision rules and different information; usually, no agents have global information, and the behavioural rules involve bounded computational capacities—the agents are "simple". This relatively new methodology facilitates modelling agent heterogeneity, boundedly rational behaviour, non-equilibrium dynamics, and spatial processes.
>
> A particularly natural way to implement agent-based models is through so-called object-oriented programming.

Gilbert (2008) provides a more compact definition:

> First, agent-based modelling is a form of computational science. That is, it involves building models that are computer programs. The idea of modelling is familiar in most of the social sciences: One creates some kind of simplified representation of "social reality" that serves to express as clearly as possible the way in which one believes that reality operates.

For a deep understanding of these definitions, first of all we need to contextualize ABMs. As pointed out in Terna (2015), models, which are simplified illustrations of the reality, can be constructed in one of the following ways:

- *Verbal argumentation.* The intrinsic flexibility of this approach prevents to make calculations, what-if investigations and tests.

- *Mathematical equations.* Using statistics and econometrics, it is possible to make calculations and tests, but they provide little flexibility and realism.

- *Agent-based computer simulation* (Ostrom, 1988; Gilbert and Terna, 2000). On one side, this approach preserves flexibility through the use of a computer code, which allows generating agents responding to stimuli coming from the external environment and from other agents, and on the other side, it preserves computability.

The importance of ABMs has dramatically increased in the last years. This is testified by the following words of Trichet (2010), the former President of the European Central Bank:

> When the crisis came, the serious limitations of existing economic and financial models immediately became apparent. Arbitrage broke down in many market segments, as markets froze and market participants were gripped by panic. Macro models failed to predict the crisis and seemed incapable of explaining what was happening to the economy in a convincing manner. As a policy-maker during the crisis, I found the available models of limited help. In fact, I would go further: in the face of the crisis, we felt abandoned by conventional tools.

Therefore, standard economic models were not able to predict the crisis, neither to explain it, nor to provide adequate tools to policy-makers in order to solve it. Quoting again Trichet:

> (...) The atomistic, optimizing agents underlying existing models do not capture behaviour during a crisis period. We need to deal better with heterogeneity across agents and the interaction among those heterogeneous agents. We need to entertain alternative motivations for economic choices. Behavioural economics draws on psychology to explain decisions made in crisis circumstances. Agent-based modelling dispenses with the optimization assumption and allows for more complex interactions between agents. Such approaches are worthy of our attention.

These arguments are aligned to the ones of Weinberg (2002), according to whom reality is not equation-based, but intrinsically agent-based. ABMs are able to produce artefacts of actual systems, so that we can apply statistics and econometrics to the outcomes of the simulations and compare the results with those obtained by applying the same tests to actual data.

ABMs can be seen as a powerful tool able to generate knowledge and thus used to understand better the reality; quoting Axelrod and Tesfatsion (2005):

> Simulation in general and ABM in particular, is a third way of doing science in addition to deduction and induction. Scientists use deduction to derive theorems from assumptions, and induction to find patterns in empirical data. Simulation, like deduction, starts with a set of explicit assumptions. But unlike deduction, simulation does not prove theorems with generality. Instead, simulation generates data suitable for analysis by induction. Nevertheless, unlike typical induction, the simulated data come from a rigorously specified set of assumptions regarding an actual or proposed system of interest rather than direct measurements of the real world. Consequently, simulation differs from standard deduction and induction in both its implementation and its goals. Simulation permits increased understanding of systems through controlled computational experiments.

Hence, ABMs can be assimilated to abduction, i.e., inference to the best explanation, which consists in choosing the hypothesis that, if verified, provides the simplest and most likely explanation of the actual evidence.

Axtell (2000) identifies three main uses of ABMs, useful in the following three circumstances respectively:

(i) Models as classical simulation: they are formulated and completely solved

(ii) Partially soluble models: they are made by artificial agents as complementary to mathematical theorizing

(iii) Intractable models: agents are not bounded rational, they develop self-generated behavioural rules (Terna, 2015)

As far as the first use, it is mostly related to *what-if* investigations. The third use instead, is related to the abductive interpretation of ABMs as tools to improve knowledge, previously discussed.

In general, ABMs could represent the starting point of the quest for microfoundations of the economic theory. Quoting Hoover (2013):

> The object of reductionism in economics—the so-called microfoundations of macroeconomics —is adequately to ground or replace higher level causal analysis with an analysis of the day-to-day interactions of people. The object is not to purge intentionality, but to reclaim it.

2.1.3 Advantages of Agent-based Models

Referring to Boero at al. (2015), ABMs represent an extremely powerful and flexible tool for scientific investigation that allows understanding socio-economic phenomena, surmounting some of the most significant limits of standard equation-based modelling.

As a matter of fact, as Boero (2015) highlights, ABMs introduce more realism in economic inquiry, in particular in terms of:

- *Integration of Theory and Data***.** In Economics, theoretical and empirical analyses are typically disconnected, mainly due to the use of nonflexible tools which impose a trade-off between tractability and realism (Lawson, 2003). In fact, traditional economic theory makes extensive use of equation-based models, based on the unrealistic assumption that agents are utility maximizers.

However, empirical data often do not corroborate theoretical models. On the contrary, ABMs overcome the above mentioned trade-off and allow for integration between theoretical and empirical knowledge.

- *Causality.* As pointed out in Epstein (2006), ABMs have an "emergentist" and "generativist" nature. They permit to model in a realistic way the mechanism generating a given phenomenon and therefore to detect its causes. In contrast, econometric models relying on equation-based models often have difficulties in finding causal relations.

- *Uncertainty.* Being able to address causality implies being able to address uncertainty. In fact, ABMs allow disentangling between "epistemic uncertainty", due to the inadequacy of the model, and "aleatory uncertainty", i.e., the intrinsic uncertainty of the human decision-making process. Both causal analysis and understanding of uncertainty allow economists to conduct *what-if* evaluations and thus help policy-makers in making decisions.

- *Heterogeneity.* In standard economic models, heterogeneity is minimal since they are based on the idea of representative agent, i.e., the typical decision-maker having features equivalent to population average. On the contrary, ABMs can deal with a huge number of agents having totally different features.

- *Interaction.* A representative agent cannot interact with others since it represents them. ABMs, instead, have the capability to model realistic interaction, for instance social networks.

- *Scalability.* The complexity of socio-economic events is related to the fact that they are usually caused by the interplay of many factors, characterized by different temporal and spatial scales. ABMs have the great advantage of accounting for scalability and allowing relations between distinct scales. In a similar way, ABMs allow considering distinct social networks at the same time and their relations.

- *Modularity.* Different ABMs can be integrated, facilitating the development of scientific knowledge. The model development process is supervised by modularity, in accordance with analytical principles.

- *Interdisciplinary*. ABMs represent a bridge between several disciplines, such as Economic Psychology, Experimental Economics, Neuroeconomics, and Behavioural Economics, to mention just a few.

Differently from traditional economic models, they capture the social dimension and the complexity of the decision-making process at the individual or firm level.

In conclusion, according to Boero (2015), ABMs do not represent the panacea for all Economics ill, but, if used in an appropriate way, they can give a great contribution to alleviate them.

2.1.4 Disadvantages of Agent-based Models

Referring to Terna (2015), the main problems concerning ABMs are related to the following aspects:

(i) The difficulty in comprehending them completely, without having previously analysed the program that allows running the simulation.

(ii) The risk of coding errors that may lead to wrong results.

(iii) The impossibility of considering the whole set of potential hypotheses (including behavioural rules) to find the best explanation, when adopting abductive thinking.

The first problem may be solved with the development of standardized tools and a specific protocol applied to them. The first attempt to achieve this goal has been Swarm, introduced in the mid-1990s (Minar *et al*., 1996). As far as the second problem, on one side, it is possible to use the tools mentioned before, on the other side, one could run the code using two different and independent tools programmed by two different individuals and check whether the results are similar in both cases. Finally, one way to surmount the last problem is using neural networks, which memorize automatically created behavioural rules on the basis of reinforcement learning techniques. An alternative way is the use of genetic algorithms, allowing evaluating variations in the parameters and behavioural rules.

Once behavioural rules are generated, it is possible to represent cognitive agents. Quoting Sun (2006, p.17):

> What makes computational social simulation, especially computational cognitive social simulation (based on detailed models of cognitive agents), different from the long line of social theories and models (such as utility theory and game theory) includes the fact that it enables us to engage with observations and data more directly and test various factors more thoroughly. In analogy with the physical sciences (...), good social theories may be produced on the basis of matching theories with good observations and data. Cognitive agent-based computational social simulation enables us to gather, organize, and interpret such observations and data with cognition in mind. Thus, it appears to be a solid means of developing social-cognitive theories.

2.1.5 What Is An Agent?

There is no universal and precise definition of the term "agent". Bonabeau (2001) defines agents any type of independent components, without specifying their behaviour. Other authors point out that these components must have an adaptive behaviour, i.e. they can learn from their environments and transform their behaviours on the basis of their experiences. According to Casti (1997), agents should have both base-level rules which make them react to the environment, and a higher-level set of "rules to change the rules" which allow adaptation. Jennings (2000), instead, underlines the ability of agents to take independent decisions, which means that they are autonomous and active rather than passive. Even if modellers do not agree on a unique definition, there is agreement on the fundamental characteristics that agents have. As Macal and North (2007) highlight, the main features of agents are:

(i) Identifiability. An agent is an individual characterized by certain features and rules which determine its behaviour and decision-making capacity.

(ii) Discreteness. Agents are discrete in the sense that they have a boundary, thus everyone is able to establish whether something is part of an agent or not.

(iii) Autonomy. Agents are self-directed and independent when acting with others in their environment.

(iv) Interactivity. Each agent interacts with other agents, following certain protocols such as for communication, and react to its environment.

(v) Goal-direction. Agents may want to achieve some goals, and not necessarily to maximize their objectives.

(vi) Flexibility. Agents can learn and change their behaviours on the basis of their experience. This requires having some form of memory.

(vii) Heterogeneity. With the exception of particle systems (for instance, idealized gas particles), agents are diverse and dynamic in their attributes and behavioural rules.

These characteristics are summarized in Figure 1. Thus, agents may vary by their attributes, accumulated resources, and behavioural rules. These rules may vary depending on the level of sophistication in the decision-making process, the memory of past events, the interactions with others and the cognitive load, i.e. how much information is taken into account when making decisions.

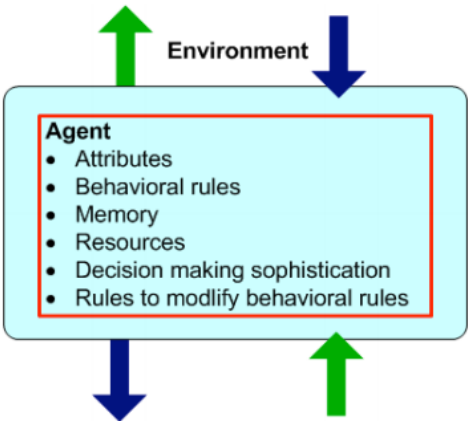


Figure 15: An Agent, Macal and North (2007)

Therefore, as Macal and North (2007) point out, it is advantageous to think in terms of agents in the following cases:

(i) When there is a natural representation as agents

(ii) When decisions and behaviours can be defined in a discrete way, i.e. with boundaries

(iii) When agents adapt and modify their behaviours

(iv) When agents exhibit dynamic strategic behaviours

(v) When agents have dynamic relationships with others and these relationships are generated and dissolve continuously

(vi) When agents create organizations, and adaptation and learning are essential at the organization level

(vii) When agents have a spatial component to their behaviours and interactions

(viii) When the past does not predict the future

(ix) When scaling-up to arbitrary levels is significant

(x) When process structural change must be an outcome of the model, rather than a model input

2.2 CONNECTING AGENTS: SOCIAL NETWORK ANALYSIS

As we have highlighted in the previous section, the main aim of ABMs is modelling agent interactions, which implies answering two fundamental questions:

- Who is connected to who?
- What are the mechanisms determining the nature of the interactions?

Networks allow describing agents' interaction patterns in a more accurate way. They matter because they are the underlying structure of our lives, and without understanding their logic we cannot change their programmes to exploit their flexibility to our scopes, and we end up adapting ourselves to the instructions received from their unseen codes. Networks are the Matrix (Castells, 2004, p.224). They are everywhere; we can find networks in any field such as, biology, physics, mathematics, economics, computer and natural sciences (Caldarelli, 2010). In what follows we will discuss in more detail the concept of network, taking both a quantitative and qualitative approach. The reason is that networks represent an essential element of our simulation model.

2.2.1 Networks: A Quantitative Approach

As Caldarelli (2010) points out, even if networks are different from one another, they share similar properties; in particular one can think that there is a universal formation mechanism which, once understood, can allow prediction of the evolution of the network.

A network is made of several interacting components, characterized by the fact that it is not possible to predict their collective behaviour in terms of the components. This is the reason why networks are related to the science of complexity.

Relying on Caldarelli (2010), technically, a network is any real system that can be described via a mathematical object, namely, a *graph*, indicated by the mathematical symbol *G(n,m).*

Graphs are characterized by a set of *n* points, called *vertices* (also known as *nodes*), and a set of *m* connections between them, called *edges* (also known as *links*), where parameters n and m are not independent of each other and:

(i) The number *n* of vertices indicates the graph *order*.

(ii) The number *m* of edges indicates the graph *size*.

The maximum number of edges in a graph of order *n* without self-edges (i.e., edges between a vertex and itself, also known as loops) is $mmax= n(n - 1)/2;$ the reason is that there are *n* possible initial points and for each one of them *n-1* endpoints, and we need to consider twice the path from one vertex to another (so we have to divide by 2). If self-edges are present instead, there are *n* more edges to be considered, hence $mmax= n(n - 1)/2 + n= n(n+1)/2.$

It is possible to distinguish two types of graphs:

(i) *Directed* graph: Edges have arrows, i.e., they can be crossed in one direction only (for example, hyperlinks in an HTML document).

(ii) *Weighted* graph: Every edge has been assigned a value (for example, in a transportation network, the value assigned to each edge could be the maximum load authorised).

Figure 2 illustrates two graphs, both of order 7 and size 6, but the one on the left is undirected, i.e. edges have no orientation-the edge (A, B) is identical to the edge (B, A)-, while the one on the right is directed.

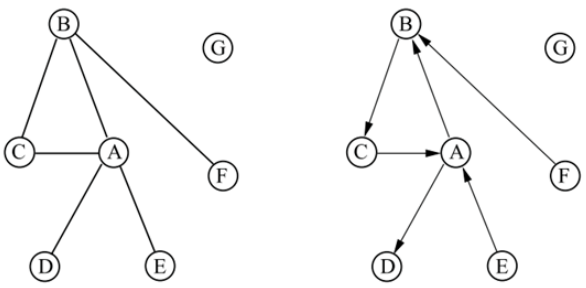


Figure 2: On the left: undirected Graph *G(7,6),* on the right: directed Graph *G(7,6)* (Caldarelli, 2010).

In order to represent the structure of a graph, the *adjacency matrix A(n,n)* can be used, where each element *aij* represents the connection between vertices *i* and *j*, and thus can be equal to either 0 or 1.

Figure 3 illustrates two adjacency matrices, where the diagonal elements, representing the loops, are equal to 0. It is worth noting that the adjacency matrix on the left is symmetric (i.e., *aij*=*aji*), which is possible only when the graph is undirected, while the one on the right is not symmetric since the graph is directed (for instance, there is only one edge going from vertex 2 to vertex 1, i.e. *a21*=1 but *a12*=0).

$$A = \begin{pmatrix} 0 & 1 & 0 & 1 \\ 1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \\ 1 & 1 & 1 & 0 \end{pmatrix} \qquad A = \begin{pmatrix} 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 \end{pmatrix}$$

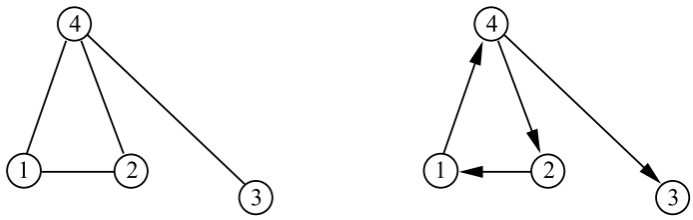


Figure 3: Representation of a graph through an adjacency matrix (Caldarelli, 2010).

2.2.1.1 Basic Quantities

It is possible to define the following basic quantities, which depend on the features of a single vertex and its neighbours:

(i) *Degree* of a vertex. It is the number of edges per vertex. The sum of the degrees of all vertices is an even number, namely, it is twice the total number of edges-because each edge contributes to the degree of the starting vertex and to the degree of the ending vertex-.

- If the degree is even, the vertex is a crossing point, i.e., it is possible to enter the vertex through one edge and exit through the other.
- If the degree is odd, the vertex is the starting or the ending point of a certain path.

The degree *ki* of a vertex *i* can be obtained by fixing a row in the adjacency matrix *A(n,n)*, and computing the sum of the elements in each column, as

$$k_i = \sum_{j=1,n} a_{ij}.$$

Moreover, if we consider a directed graph, we can identify the *in-degree* and *out-degree* of a vertex, as

$$k_i^{in} = \sum_{j=1,n} a_{ji}$$
$$k_i^{out} = \sum_{j=1,n} a_{ij}$$

It is worth noting that, in this case, generally the adjacency matrix is not symmetric, hence *aij*=1 if and only if an edge starts from vertex i and reaches vertex j, while *aji*=0. For instance, in Figure 2, in the undirected graph on the left, the *degree* of vertex C is 2 and the *degree* of vertex A is 4; in the directed graph on the right, the *in-degree* of vertex C is 1 and its *out-degree* is 1, while the *in-degree* of vertex A is 2 and its *out-degree* is 2.

If we consider a weighted graph, the *weighted degree* k_i^w of a vertex i can be obtained as

$$k_i^w = \sum_{j=1,n} a_{ij}^w.$$

It is worth noting that the degree represents the most immediate property of a vertex. Hence, if one is interested in analysing the presence of a community, defined by vertices having similar properties, it is common to analyse the presence of correlation between vertices having similar degree. If high-degree vertices are connected to each other, the network is characterized by the so-called *assortative mixing* or *assortativity*. If instead high-degree vertices are linked to low-degree ones, *disassortative mixing* or *disassortativity* realizes (Newman, 2002a).

These properties can be visualized in Figure 4, by plotting the average degree <*knn*> of the neighbours of a vertex *i* versus the degree *k* of *i* (Pastor-Satorras, Vázquez and Vespignani, 2001).

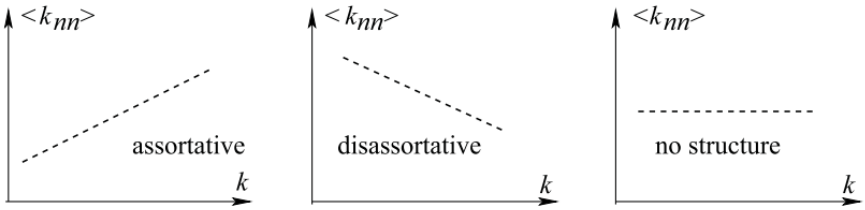


Figure 4: Possible relationships between the average degree <*knn*> of the neighbours and the degree *k* of the vertex origin (Caldarelli, 2010).

As shown in the figure above, if the average degree <*knn*> is an increasing function of the degree *k*, then the network has *assortative mixing*; i.e., a vertex of large degree is connected to other vertices of large degree. If instead <*knn*> is a decreasing function of the degree *k*, the network has *disassortative mixing*, i.e., a vertex of large degree is linked to single edge vertices.

(ii) *Connectedness* between vertices. Vertices *i* and *j* are said to be *connected* if there is a path between them. If this happens for every pair of vertices, the graph is connected.

(iii) *Distance* between two vertices *i*, *j*. It is the number of edges in the shortest path connecting vertex *i* and vertex *j*, indicated as *dij*. Hence, the neighbours of a vertex *i* are given by all the vertices that are connected to vertex *i* by a unique edge. This can be computed as

$$d_{ij} = min\{\sum_{k,l \in \mathcal{P}_{ij}} a_{kl}\}$$

where pij indicates the path from vertex *i* to vertex *j*.

Given that summing the *aij* and summing their inverse is equivalent-since all edges are equal to 1-the distance *dij* can be computed also as

$$d_{ij} = min\{\sum_{k,l \in \mathcal{P}_{ij}, a_{kl} \neq 0} \frac{1}{a_{kl}}\}$$

If we consider a weighted graph, the distance can be computed as the sum of the inverse of the weights

$$d_{ij}^{w} = min\{ \sum_{k,l \in \mathcal{P}_{ij}} \frac{1}{a_{kl}^{w}} \}$$

i.e., the distance depends on the weight of the edge: the larger the weight, the smaller the distance between two vertices.

(iv) *Diameter* of a graph. It represents the greatest distance between any pair of vertices in the graph, indicated as *D*.

(v) *Clustering*. It indicates the number of neighbours of the same vertex that are also neighbours of each other. It is possible to compute the *clustering coefficient Ci*, which is precisely given by the fraction of actual edges over all the possible edges connecting vertices *i*, *j*, *k* in the graph.

$$C_i = \frac{1}{(k_i)(k_i - 1)/2} \sum_{j,k} a_{ij} a_{ik} a_{jk}.$$

For instance, in Figure 5, the vertex in the middle has three neighbours that are connected in only one (solid line) of the three possible ways (dashed lines), therefore, *Ci* = 1/3. The three connected vertices create the grey triangle; this is why sometimes *Ci* is identified by the number of triangles the vertex belongs to.

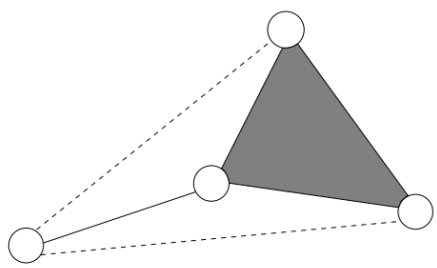


Figure 5: Clustering (Caldarelli, 2010).

If we consider a directed graph, the notion of clustering coefficient is extended to the ones of in-degree and out-degree clustering coefficients, after deciding to consider one of the two directions of the edge connecting the neighbours. They can be computed as

$$C_i^{in} = \frac{1}{(k_i^{in})(k_i^{in}-1)/2} \sum_{j,k} a_{ji} a_{ki} \frac{(a_{jk}+a_{kj})}{2},$$

$$C_i^{out} = \frac{1}{(k_i^{out})(k_i^{out}-1)/2} \sum_{j,k} a_{ij} a_{ik} \frac{(a_{jk}+a_{kj})}{2}.$$

If we consider a weighted graph, the clustering coefficient can be computed as

$$C_i^w = \frac{1}{\langle a^w \rangle^3 (k_i)(k_i-1)/2} \sum_{j,k} a_{ij}^w a_{ik}^w a_{jk}^w \quad , \quad \langle a^w \rangle = \frac{1}{n} \sum_{ij} a_{ij}^w$$

where the quantity on the right represents the average weight of an edge. In fact, in a weighted graph, if an edge is missing, it is necessary to add to the term *(ki(ki – 1))/2*, accounting for the total number of edges that can be represented, also the weight of the missing edge.

2.2.1.2 Global quantities

Global quantities depend on the state of the entire system, i.e. on shape of the whole network. The most important are:

(i) *Centrality* of a vertex. It represents the importance of a vertex. It is possible to identify different measures of of a vertex *i*; the easiest one is given by *c(i)*, the inverse of the average distance of vertex *i* from all the others. If it is maximal, i.e. the average distance is the minimum one, it means that vertex *i* is the most central vertex.

$$c(i) = \frac{1}{\sum_{j=1,n} d_{ij}}$$

Similarly, we can measure the centrality of an edge by considering the inverse of the average distance of one edge from all the others.

(ii) *Betweenness*. It represents another measure of centrality, which makes sense when dealing with transportation networks (water, electricity, information, etc.), characterized by a flux on the edges of the graph. Assuming that on each edge there is a uniform load, i.e. any edge has the same capacity of the others, it is possible to compute two quantities:

- *Site-betweenness.* It is given by the number of times one vertex *i* is crossed along the shortest path between two other vertices *j* and *l*, *d(j, l).*

$$b(i) = \sum_{\substack{j,l=1,n \\ i \neq j \neq l}} \frac{\mathcal{D}_{jl}(i)}{\mathcal{D}_{jl}}$$

where *Djl* is the number of all possible shortest distances between vertex *j* and vertex *l* and *Djl(i)* indicates the fraction of shortest paths passing through *i*.

- *Edge-betweenness*. It represents a generalization of the previous quantity, referred to the number of shortest paths that pass through a certain edge connecting a pair of vertices. Edges with high betweenness are the ones that connect parts of the graph that would be unconnected otherwise.

Given that it requires more time to compute the betweenness along graphs with a huge number of vertices, several methods to find an approximate value of this quantity have been identified.
For instance, one could check whether, after a certain number of deletions of edges and vertices, a certain graph is unaffected, in terms of the diameter and the average distance with respect to the fraction of removed vertices. It is possible two identify two classes of deletions (Albert, Jeong, and Barabási 2000, 2001): the *random* failure, where a vertex is randomly eliminated no matter its importance or centrality in the network, and the *attack*, where a vertex is eliminated on the basis of a probability related to its importance (usually represented by the degree).

(iii) *Robustness*. It indicates the ability of the network to maintain its integrity and perform its function in the face of attack (such as vertex or edge removal).

2.2.1.3 Scale-free Networks

It is of utter importance to highlight a particular class of networks, called scale-free networks. They can be found in a variety of different fields such as, biology, computer

science, physics, geology, social systems, finance or economics and they are characterized by a sort of "universality" since they display some common features:

(i) *Statistical distribution P(k) of the degree k.* There is evidence that scale-free networks exhibit an important statistical property (Barabási, 2002; Buchanan, 2002; Dorogovtsev and Mendes, 2003; Pastor-Satorras and Vespignani, 2004), i.e. the probability distribution of the degree *P(k)* follow a power law

$$P(k) \propto k^{-\gamma}$$

as well as the betweenness distribution *P(b)*

$$P(b) \propto b^{-\gamma_b}$$

The properties of the two distributions can be connected (Goh, Kahng, and Kim, 2001; Barthélemy, 2004) by the following relationship

$$3 \geq \gamma > 2$$

$$\Rightarrow$$

$$\gamma_b \geq \frac{\gamma + 1}{2}$$

where, in the second expression, the equality holds whenever the network is a tree (Barthélemy, 2004).

(ii) *Statistical distribution P(d) of distances d.* In scale-free networks, the distribution *P(d)* of distances *d* is similar and it is usually peaked around small values like 4, 5, and 6. Moreover, the average value of *d* displays a logarithmic dependence on the number *n* of vertices the network has (Szabó, Alava, and Kertész, 2002). This feature is known as *small-world effect*, since typically, in a social graph, a small number of edges (relationships) can connect vertices (individuals) lying in two different parts of the graph (Milgram, 1967). This effect has been found in the Internet (Faloutsos, Faloutsos,

and Faloutsos, 1999), in the WWW (Broder *et al*., 2000), in the network of sexual contacts between people (Liljeros *et al*., 2001), and in the network of co-authorship composed by scientists writing a paper together (Newman, 2001a, 2001b).

(iii) *Clustering coefficient C(k) of a node with degree k.* Scale-free networks tend to display *assortative mixing* or *disassortative mixing*. This can be observed either by plotting the average degree of the neighbours of a vertex *i* as a function of the degree of *i*, as previously said, or by plotting the clustering coefficient of a vertex *i* as a function of the degree of *i* (in fact, in large clusters, neighbours usually have a large degree). In both cases, if the relation is positive, there *is assortative mixing.*

Figure 6 shows some examples of real networks and their general features: the order, i.e. the number of vertices, the average degree $<k>$, the average path length l, the clustering coefficient C, and the value of γ, the exponent for the degree distribution. The size of each network E, i.e. the number of edges, can be easily computed as $E = N <k> / 2$, since the average degree $<k>$ is defined as twice the number of edges, divided by N, the number of vertices.

	Network	Order	$\langle k \rangle$	ℓ	C	γ
1	Internet	3700 - 10500	3.6 - 4.1	3.7	0.21 - 0.29	2.1
2	WWW	$2 \cdot 10^8$	15	16	–	2.1
3	Movies	225, 226	61	3.65	0.79	2.3
4a	Sex (males)	2810	22.63	–	–	1.6
4b	Sex (females)	2810	6.3	–	–	2.1
5	Co-authors	56627	173	4	0.726	1.2
6	Yeast	1870	2.395	–	–	2.4
7	Drosophila	3039	2.40	9.4	–	1.26
8	Stock	240	2.67	18.7	0.08	2.0
9	Words	460902	70.13	2.67	0.437	2.7
10	Flora	282	14	2.65	0.28	2.6

Figure 6: General features of some real networks (Caldarelli, 2010).

2.2.1.4 Graph Structures

According to Caldarelli (2010), it is important to distinguish between two apparently very similar quantities:

(i) *Cluster*. It indicates a part of the graph characterized by a larger number of internal edges than external ones.

(ii) *Community*. It can be defined as a set of vertices having the same topological properties or, less formally, the same "preference" in their connections. For instance, a set of vertices sharing the same edges represent not only a cluster, but also a community because they have a common property.

As shown in Figure 7, a highly clustered subgraph usually signals the presence of a community; in other words, a cluster can be always associated with a community.

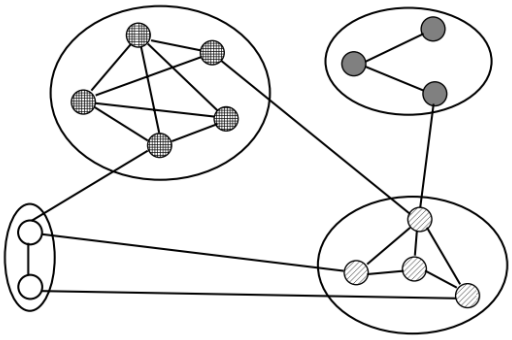


Figure 7: Four communities in an extremely clustered subgraph (Caldarelli, 2010).

In contrast, communities tend to correspond to clustered subgraphs, but not always. For instance, in Figure 8, the set of dark vertices pointing towards the set of light ones form two communities but they do not form two clusters since the vertices in each set are not linked to each other.

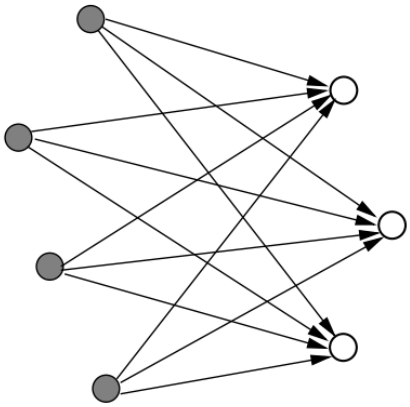


Figure 8: A simplified representation of a typical structure of the World Wide Web (Caldarelli, 2010).

These quantities are relevant not only to characterize the graph from a topological point of view, but also to provide information on the formation and functionality of the

network. In fact, the whole network is usually obtained as a merge of several subgraphs (the World Wide Web is an example).

2.2.1.5 Classes of Vertices

In directed graphs, it is possible to differentiate between vertices on the basis of their nature; this allows to compute communities or to define the spanning trees of the structure.

For instance, considering the World Wide Web, where the vertices are web pages and edges can point to (outgoing edges) or from (ingoing edges) a certain web page, it is possible to distinguish between:

(i) *Hubs*. They can be defined as web pages characterized by a great number of outgoing edges, i.e. they point towards a great number of *authorities*. For instance, Yahoo is appropriate to reach as many other web pages as possible.

(ii) *Authorities*. They indicate those web pages characterized by a great number of ingoing edges, i.e. they are pointed by a great number of *hubs*. For instance, on-line newspapers typically have a large number of ingoing edges, which is a way of attesting the importance of their content.

In Figure 8, the grey vertices are the hubs, while the light ones are the authorities of the graph.

A similar interpretation applies to the case of food webs, where the vertices are the species and directed edges represent predations going from the prey towards the predator. This allows distinguishing between basal species, which are only prey, top species, which are only predators and intermediate species, which are both prey and predator.

2.2.2 Networks: A Qualitative Approach

From the Wikibook entitled “Social network analysis: Theory and applications” (2011), we read:

> Social network analysis views social relationships in terms of network theory consisting of nodes and ties (also called edges, links, or connections). Nodes are the individual actors within the networks, and ties are the

relationships between the actors. The resulting graph-based structures are often very complex. There can be many kinds of ties between the nodes. Research in a number of academic fields has shown that social networks operate on many levels, from families up to the level of nations, and play a critical role in determining the way problems are solved, organizations are run, and the degree to which individuals succeed in achieving their goals. In its simplest form, a social network is a map of specified ties, such as friendship, between the nodes being studied. The nodes to which an individual is thus connected are the social contacts of that individual. The network can also be used to measure social capital –the value that an individual gets from the social network. These concepts are often displayed in a social network diagram, where nodes are the points and ties are the lines.

Originally, Social network analysis (hereafter, SNA) has studied static networks that do not evolve over time due to agent behaviour. More recently, instead, it has been focusing on the dynamics of real-world networks (Barabási 2002), and thus on how networks grow, how information is spread and which kind of relationships are created.

2.2.2.1 Advantages of Network Analysis

Network analysis is particularly advantageous when one or more of the following mechanisms is taking place:

(i) Transmission. There are some transfers or flows among nodes, which can involve physical or immaterial elements.

(ii) Adaptation. Nodes can evolve by adapting to environmental changes.

(iii) Exclusion. The position of nodes in the network is crucial in determining their opportunities, by allowing the emergence of new properties from relations, and limits.

(iv) Binding. Bounded nodes have some particular properties. An example of this mechanism is provided by Burt, sociologist and Professor at the University of Chicago.

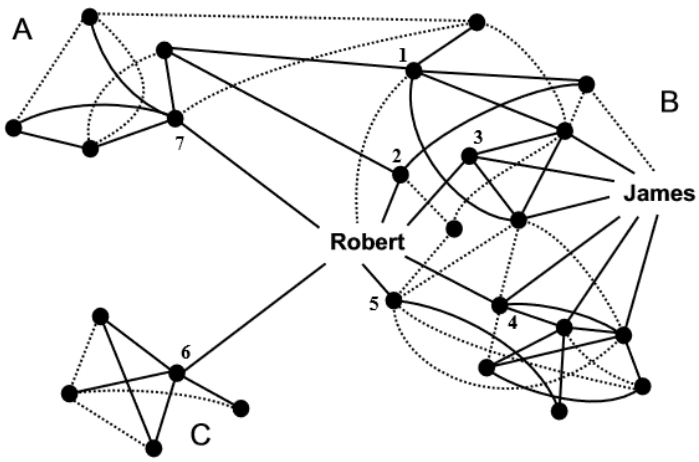
Given the importance of his contribution for our analysis, we illustrate his thinking in the following paragraph.

2.2.2.1.1 Structural Holes and Entrepreneurship

Burt (2003) highlights the importance of social network analysis, in particular, the concepts of structural holes and social capital in a social network.

According to him, a social network is a social structure characterized by the relationships between social actors (such as individuals, firms, organizations), where each individual's behavior is influenced by those around him. Hence, the unit of analysis is an entity consisting of the individuals and the linkages connecting them.

In order to have a visual idea of this concept, we can consider the sociogram below: dots represent individuals, solid lines indicate strong relations (i.e., where information flows more frequently or more clearly between people), dashed lines indicate weak relations. We can distinguish three clusters of dense connections (A, B and C), linked by some bridge relations.



Density Table of Relations Within and Between Groups

.65			Group A (5 people and 8 ties; 5 strong, 3 weak)
.05	.25		Group B (17 people and 41 ties; 27 strong, 14 weak)
.00	.01	.65	Group C (5 people and 8 ties; 5 strong, 3 weak)

Figure 9: Social Organization, Burt (2001)

According to Burt (2003), there is a greater degree of homogeneity in terms of opinion, behaviour and activities, within than between groups. Moreover, whenever people focus uniquely on activities inside their own group, a structural hole is generated. They can be defined as holes in the information flow between groups since they separate diverse sources of information that are never redundant or overlapping.

Structural holes create a competitive advantage for an individual who has a network that spans the holes; since she has access to different ways of thinking and behaving that allow her to translate information across groups and also detect good ideas.

For instance, in Figure 1.1, both Robert and James have one weak tie and six strong ties and are connected to everybody within group B. However, Robert has the best location: he plays the role of a broker in the network since, through his strong relationships with 7 and 6, he has the opportunity to transfer information from groups A and C to group B. More precisely, the importance of Robert can been addressed by considering the indices of Network constraint and Network betweenness; which measure the redundancy of contacts (law) and the amount of indirect connections (high), respectively.

Robert can be seen as an entrepreneur: "a person who adds value by brokering connections between others" (Burt 1992), i.e. by building bridges between disconnected parts of the social network whenever it is valuable to do so.

Similarly, Stewart (1990) highlights that entrepreneurs are interested in "those points in an economic system where discrepancies of evaluation are the greatest" and they try to "construct bridging transactions". He explains that:

> Bridging roles are based on the recognition of discrepancies of evaluation, which requires an edge in information about both sides of the bridge. Because this requires an information network, bridgers will commit time, energy, travel and sociability to develop their personal networks. For many entrepreneurs, their most significant resource is a ramifying personal network.

2.2.2.1.2 Structural Holes and Social Capital

Social capital can be defined as the stock of social trust, norms and networks that people can rely upon in order to solve everyday problems. It works through repeated exchanges

among people over time and at different levels, such as society, city, neighbourhood, family.

When networks are denser, coordination, communication and cooperation among the members of a community are more likely and the efficiency of society is improved.

This notion is clearly expressed by Coleman (1990):

> Social capital is defined by its function. It is not a single entity but a variety of different entities having two characteristics in common: They all consist of some aspect of social structure, and they facilitate certain actions of individuals who are within the structure. Like other forms of capital, social capital is productive, making possible the achievement of certain ends that would not be attainable in its absence.

Also Bourdieu (1992) focuses on social capital, he explains:

> Social capital is the sum of the resources, actual or virtual, that accrue to an individual or group by virtue of possessing a durable network of more or less institutionalized relationships of mutual acquaintance and recognition.

Burt (2001) shares these definitions and refuses the human capital theory according to which people who perform better have an higher stock of resources, such as know-how, skills, abilities, talents, intelligence.

He believes that what makes the difference is social capital, which is neither traditional capital nor human capital; it refers to resources that are stored in human relationships.

As a consequence, better connected people have a competitive advantage and enjoy higher returns.

In particular, he defines four network mechanisms in order to define social capital:

(i) **Contagion**: Market information is unclear so peer behaviour is imitated.

(ii) **Prominence**: Market information is unclear so the behaviour of a prominent individual or group is followed.

(iii) **Closure**: Closed networks have a competitive advantage since they reduce the risk of cooperation by facilitating communication and control.

(iv) **Brokerage across structural holes**: Networks that bridge structural holes have a competitive advantage since they increase the value of cooperation by providing access to diverse information.

Figure 10 illustrates what are the effects of brokerage across structural holes.

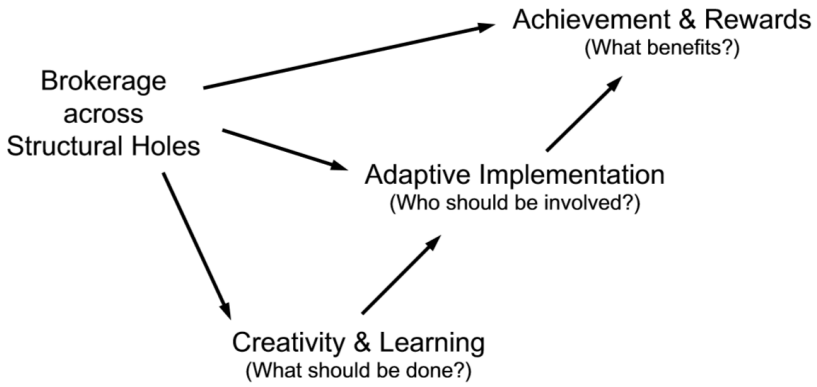


Figure 10: Effects of Brokerage across Structural Holes, Burt (2001)

First, brokerage stimulates creativity: good ideas are developed through connections across structural holes, i.e. contacts with different, contrasting interpretations.
This argument was already considered by Adam Smith (1982 [1766]), who said that "when the mind is employed about a variety of objects it is somehow expanded and enlarged".
Similarly, according to John Stuart Mills (1987, [1848]):

> It's hardly possible to overstate the value, in the present state of human improvement, of placing human beings in contact with other persons dissimilar to themselves, and with modes of thought and action unlike those with which they are familiar. Such communication has always been, and is peculiarly in the present age, one of the primary sources of progress.

More recently, Stroebe and Diehl (1994) have provided empirical evidence that brainstorming groups made of individuals having heterogeneous backgrounds have higher performance and better ideas thanks to the exchange of information across structural holes.

Second, brokerage facilitates adaptive implementation, i.e. it allows the possibility to adapt initial plans to new and changing events. Therefore, brokers are not only more creative but also they are more able to adapt to problems and changes, so that valuable projects can be implemented.

Third, there is empirical evidence that people who bridge "structural holes" in social networks gain significant payoff advantages. For instance, managers who broker connections across groups have early promotions, higher compensations, better performance evaluations, more successful teams.

Besides, Burt (2003) considers four possible levels of brokerage that allow an individual to create value:

(i) Informing people about interests and difficulties in other groups in order to avoid misunderstandings and conflicts among them.

(ii) Introducing into a group useful practices and believes of other groups.

(iii) Finding analogies between groups.

(iv) Combining activities and knowledge across groups.

Hence, brokerage can be seen as the real engine for productive change.

2.2.2.2 Some Network Examples

Cioffi-Revilla (2014) highlights how social networks are spread in many different fields:

> Social networks consisting of actors and social relations are ubiquitous across the social science disciplines. Networks are consequential and frequent in anthropology, economics, sociology, political science, and psychology –the Big Five social sciences- as well as interdisciplinary areas such as communication, management science, international relations, history, and geography, especially human geography.

Caldarelli (2010) provides a list of the fields in which it is common to find networks:

(i) Natural sciences. Some examples are given by

- Networks in cell biology
  - Protein-protein interaction network
  - Metabolic networks
  - Gene regulatory networks
- Ecological networks
  - Food webs
  - Taxonomies
- Geophysical networks
  - River networks

(ii) Information technology. Some examples are given by

- Technological networks
  - Internet
  - E-mail networks
  - World Wide Web

(iii) Socio-economic sciences. Some examples are given by

- Social and cognitive networks
  - Networks of scientific papers
    - Co-authorship networks
    - Citation network
  - Contact networks
    - Sexual networks
    - Epidemics
  - Linguistic networks
    - Co-occurrence networks
    - Word associations
  - Wikipedia
- Socio-economic networks
  - Financial networks
    - Board of directors

- Stock networks
  - Ownership networks
  - Stock price correlations
- Bank networks
- World trade web

Of particular interest are bank networks; therefore we will briefly discuss them in the following paragraph.

2.2.2.2.1 Bank networks

As Caldarelli (2010) point out, the inter-bank market can be represented as a network. In particular, the banks are represented as vertices and for each pair of banks *i* and *j* there is a directed edge going from *i* to *j* whenever bank *i* borrows liquidity from bank *j*. The exchange of money among banks is due so that each bank can always satisfy the requests of its customers even when they exceed its liquidity reserve. Moreover, central banks usually set minimum reserve requirements so that banks have to hold a fraction of their deposits and debts as reserves, in order to insure them against liquidity shocks and preserve the stability of the banking system. For instance, the European Central Bank requires each bank in the euro area to deposit on average the 2% of the overall amount of their transactions, where this percentage is computed on the 23rd of each month. Hence, each bank has the main objective of maximizing its returns and accomplishing this requirement.

As illustrated in Figure 11, it is possible to differentiate banks on the basis of their size, which depends on their transaction volumes. Larger banks are more connected and make many transactions while the opposite happens with smaller banks which make fewer operations and usually lend or borrow money from larger banks. In Figure 11, small banks are represented by light grey vertices of the smaller size while large banks are identified by dark grey vertices of the larger size. It is evident that the core of the structure is made by larger banks.

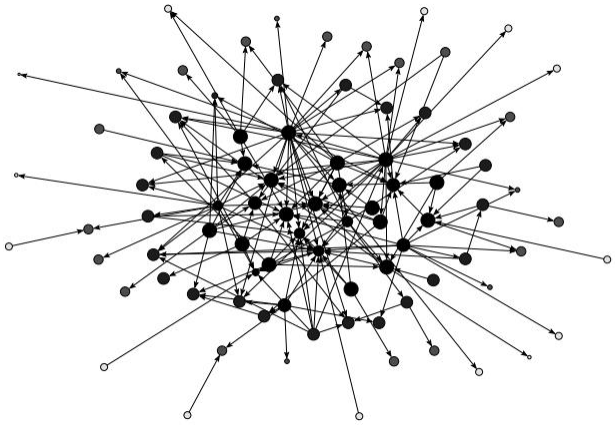


Figure 11: Representation of a typical trading day as a network (Caldarelli, 2010).

Therefore, we can divide banks in groups; for instance in Figure 12, groups 1, 2, 3, 4 have transaction volumes in the range 0-100, 100-200, 200-500, over 500 million Euros per day respectively. By illustrating the in- and out-degree frequency distributions for a certain degree *k*, Figure 12 highlights that banks of groups 1-2 are more likely to be lenders, while banks of groups 3-4 tend to be borrowers. In fact, the tail of both distributions is made of banks of group 4, but the tail of the out-degree distribution is fatter, so we can conclude that large banks tend to be mainly borrowers.

The scale of grey patterns in the plot shows that it is possible to calculate the average group of banks with degree *k*, for instance, the average group of banks with degree 10 is of banks of group 3 (while for non-integer value of the average group intermediate patterns are presented).

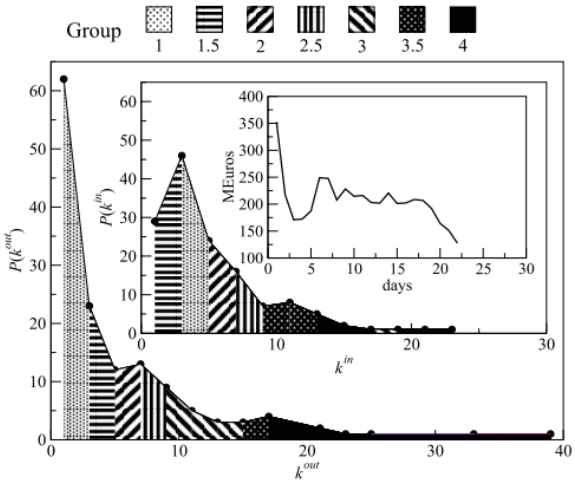


Figure 12: Representation of the in-degree frequency distribution (money lent) and out-degree frequency distribution (money borrowed) in the network (Caldarelli, 2010).

2.3 AGENT-BASED MODELS AND NETWORK ANALYSIS

The combination of ABMs and network analysis (hereafter, NA) represents a powerful tool both for policy-makers and citizens in deciding and evaluating policies in complex environments (Fontana and Terna, 2014).

On one side, ABMs are able to simulate and connect the micro-level behaviour of agents and the macro-level patterns that emerge from their interactions; adopting an approach that cannot be exploited by mathematical and econometric models. On the other side, NA allows to evaluate the effects of policies in terms of efficiency and stability over time.

The joint use of NA and AMBs is crucial for the development of Complexity economics as an alternative view with respect to that of an economy as a mechanism ruled by equilibrium that can be controlled and predicted.

2.3.1 From Agent-based Models to Network Analysis and Vice Versa

There are two ways of considering jointly ABMs and NA (Fontana and Terna, 2014):

(i) From ABMs to NA: decentralized autonomous interactions among agents, simulated by an ABM, determine the emergence of a network. This proceeding can again be interpreted in two different ways:

- According to some authors (e.g. Hamil and Gilbert, 2009; De Caux et al., 2014), agents act in order to generate a network, which can thus be seen as the objective of their interaction and therefore, it is characterized by a priori super-imposed features.
- A more innovative approach consists in considering that networks emerge as a consequence of socio-economic interactions among agents following their capabilities and internal rules, as in the real world. This will be the line of reasoning that we will try to follow.

(ii) From NA to ABMs: given that network data are easier to find with respect to behavioural data, an interesting challenge is represented by the so-called reverse engineering technique: the model is built starting from network data, therefore the network is not engineered ad hoc.

As far as the reverse engineering technique, it is described in Figure 13. A represents the real world made by actual entities and actual network, which is not perfectly known. The absence of complete information prevents from generating B, which represents an ABM, and C, which represents the emerging network. However, if data on the network is available (D), it is possible to make inference about C and therefore to understand B and A, going back to actual agents.

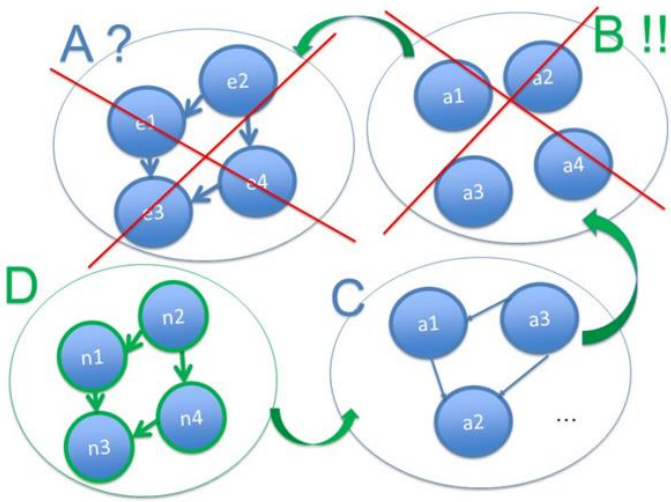


Figure 13: A: actual entities, B: ABM, C: emerging network, D: network data. Fontana and Terna (2014).

Figure 14 illustrates the difference between conventional NA and merging NA with ABMs, through the reverse engineering technique. The main drawback of NA is the focus on theoretical and static networks, rather than dynamic ones, and the inadequacy of measures of networks. ABMs add realism and dynamism to NA and overcome measurement problems.

Steps	Network Analysis	Agent-based Network Analysis
I	Take data from real world	Take data from real world (on micro-behavior of network)
II	Observe regularities	Build an ABM of the phenomenon of interest
III	Generate theoretical networks with the desired properties	Observe emerging networks (if any)
IV	Measure the distance between theoretical and actual networks by means of network statistics	Study the dynamic properties of the emerging network.

Figure 14: NA and ABMs. Fontana and Terna (2014).

As far as the way of proceeding of type **(i)**, in generating emerging networks, the most appropriate metaphor is represented by a "recipe", analysed in the next paragraph.

2.3.1 The *Recipes*

The term recipe, typically used in the field of industrial economics, can be defined as *a list of ingredients and directions for making something, especially a food preparation* (Collins English Dictionary). A recipe contains data about the properties of certain actions and their timing and whether the actions are parallel or sequential (Terna 2010, 250). Referring to Fontana and Terna (2014), technically, recipes are vectors containing sequences of numerical or alphanumerical codes, moving from one agent to another and creating events. In particular, each number or label defines an act that creates new structures and linkages, i.e. emerging networks.

For instance:

[5 1 3 2]

means: “execute step 5, then execute step 1, then execute step 3, then execute step 2”.

[5 1 (3 2 4) 7]

means: “run steps 3, 2, and 4 in a parallel way”.

[5 1 {3} 4 7]

means: “run step 3” but referring to a group of different recipes that execute that step, all together.

Therefore, the structure is simple: a time-ordered sequence of events, which are sets of small acts and steps, induce agents to behave and change their context by creating new linkages.

In order to provide a better understanding of what a recipe is and introduce it in the context of production, we refer to Terna (2015). In this case, recipes identify the passages that allow realizing goods, on the basis of market demand (a collection of orders).

As we can see in Figure 15, goods move between production units. In particular in location a1, the first order, represented by the recipe [3, 2, 4], induce a movement towards a production unit capable of executing step of type 3. Once location a2 is reached, the recipe becomes smaller: [2, 4]. Given that in location a3 both the first and the second production units are able to execute step of type 2, one solution is to choose randomly between them. Assuming that the second production unit executes step of type 2, in location a4 the recipe contains only one last step: [4], which is executed in location a5 by a production unit able to do step of type 4.

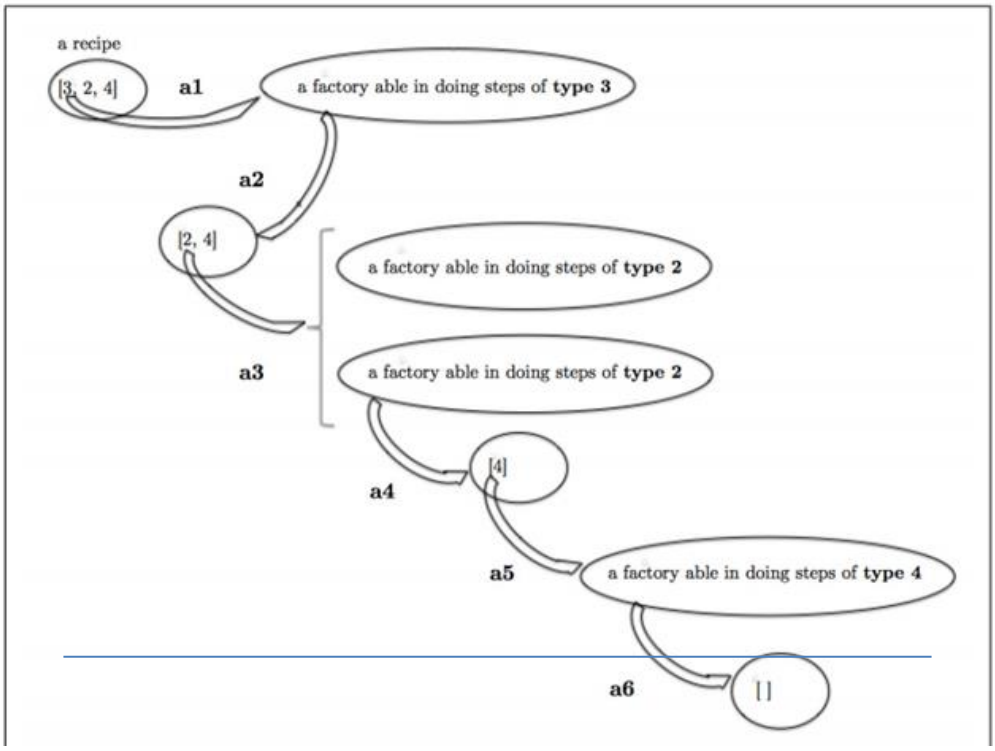


Figure 15: Movements between nodes of a recipe. Fontana and Terna (2014)

As Terna (2015) points out, what is worth noting is that the movement of orders between production units generate and exploit links among them. Therefore, agents are not asked to build a network, but a network emerges as a consequence of their behaviour.

Assuming that agents are conscious of the network, they may consider two fundamental network measures previously discussed: betweenness and centrality. In the production context for instance, a node with high betweenness may amplify its importance by increasing its activity through machine tools, while a node with high centrality may be crucial for the diffusion of knowledge, thoughts and choices.

Chapter 3

The Model

3.1 THE PROGRAM: NETLOGO

The program used for the construction of our model is NetLogo, an agent-based programming language which allows the exploration of complex phenomena, designed by Uri Wilensky in 1999 and developed at the Northwestern University Center for Connected Learning and Computer-Based Modelling. The user can provide instructions to hundreds or thousands of independent "turtles", i.e. mobile agents that reside in a world of "patches", i.e. stationary agents, all operating simultaneously. This allows analysing the connection between the micro-level behaviour of agents and the macro-level structures that arise from their interaction.

The Netlogo window is made of three tabs, which can only be viewed one at a time:

(i) The interface tab (shown in Figure 1). It is where the user can observe the model run, composed by:

- The view. It displays all the interacting turtles and patches.
- The command center. It allows using Netlogo commands directly, without introducing them in the model's procedures.
- Interface items. They are available in the toolbar. The user can choose among buttons, sliders, switcheres, choosers and inputs, which allow modifying the behaviour of agents; monitors, plots, outputs and notes, which show the outcome of their interaction.

(ii) The Information tab. It is where the user can report the information concerning the model, in order to make it understandable for other people. It is made of several sections: “What is it?”, “How it works?”, “How to use it”, “Things to notice”, “Things to try”, “Extending the model”, “Netlogo features”, “Related models”, “Credit and references”.

(iii) The Code tab. It is where the code of the model, written in different colours depending on the function of the words, is stored.

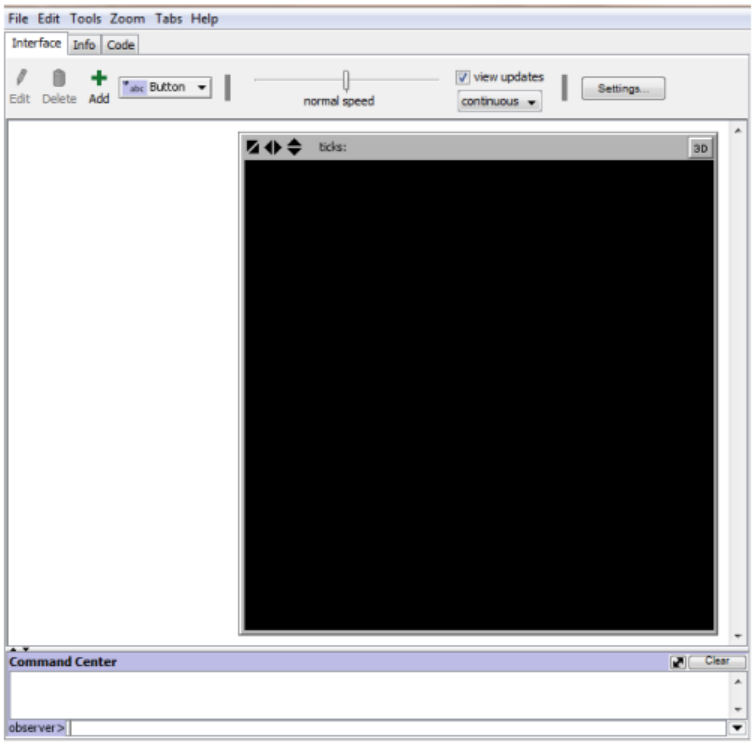


Figure 16: The Netlogo Window

In Netlogo, the four main types of agents are:

(i) Turtles. They move around in a world made by a grid of patches.

(ii) Patches. They are square pieces of ground over which turtles can move.

(iii) Links. They connect two turtles, and they are visually represented by lines.

(iv) The observer. It can be seen as an external agent who looks out over the world and provides instructions to the other agents.

When creating a model, it is possible to define turtle variables, patch variables, link variables or global variables, which are the only ones that are accessible by all agents. The user can invent new variables or use built-in variables, which are already defined in Netlogo (such as “color”, owned by all turtles and links).

3.2 INTRODUCTION

Our model tries to put together a series of considerations, analyses and ideas coming from the literature in order to provide a formalization of microcredit. The only possible way to do so is through agent-based simulation, given that it would be impossible to consider a model with optimizing agents. As we have already highlighted in Chapter 2, there are three ways to build a model: the literary method, calculus or agent-based models. Through our ABM, it is possible to represent in a computable way a set of hypotheses and descriptions in order to understand the functioning of microcredit.

Given that simulating the Chinese economy would have been a too difficult mission, our model refers to an abstract developing country, thus it can be adapted to different realities. As far as the applications of our model are concerned, we must say that our work is very theoretical: it analyses the utilization and use of microcredit in developing countries, adopting a political economy perspective.

In order to explore the hypotheses we have considered, we will refer to Epstein and Axtell (1996). According to their perspective, the three main components of any model are: the environment, the agents, and the rules governing the interaction of the agents with each other and the environment. In what follows, we are going to present our model by deeply analysing each one of these components. We start by dealing with the environment and the agents, which are generated through the “setup” button (represented in Figure 2).

Figure 17: By pressing the “setup” button on the interface, the user allows the creation of the environment and of the agents. Note that this is a “once” button, meaning that it does one action and then stops, and when the action is finished, the button pops back up.

3.3 The Environment

It identifies the space where agents interact with each other and with the environment itself. In Netlogo, it consists of a two-dimensional grid made by cells or patches. In our model, we consider the environment as a space of social relations, but also as a geographical space, in fact some of the procedures are distance related (precisely, we use the command "in-radius"). In addition, we give to one of the cells (patch sixteen sixteen) the role to store the "orders" about goods to be produced.

3.4 THE AGENTS

As Epstein and Axtell (1996) highlight, each agent is characterized by two fundamental elements:

(i) Internal states. They can be divided into:

- Fixed parameters. They do not change during the life of the agent (for instance, gender). If there are some fixed parameters which vary across the population of a model, then the population is said to be heterogeneous.
- Variables. They can change during the life of the agent, due to the interaction with other agents and the environment (for instance, wealth).

(ii) Behavioural rules. These are rules concerning conduct that agents have to obey to, shaping their day-to-day activity.

In this section, we are going to present the five types (or "breeds", in Netlogo terminology) of agents we have considered in our work. They are heterogeneous since they pursue different objectives from their interactions.

3.4.1 Financial Institutions

The crucial agent of our model is the poor who starts a microenterprise. In order to start a business, the poor needs a loan, either from the formal sector or from the informal sector, depending on whether financial institutions provide microcredit loans or not. Since the aim of our simulation is to study the impact of microcredit on the wealth level of the poor and on the society, on the interface of the programme we have inserted a switcher (reported in Figure 2), which is a visual representation for the true/false global

variable “microcredit”. The user can set the variable to either on (true) or off (false) by flipping the switcher.

Figure 18: Switcher regulating the presence of microcredit.

The user can change the number of financial institutions using the slider “number_of_financial_institutions”. Since we want to focus on the poor, in our model, these agents have two basic functions: they receive deposits from wealthy people, who do not ask for loans, and, if the switcher “microcredit” is on, they provide microcredit loans to poor people earning interests on them. They are characterized by the following attributes:

- “**funds_financial_institution**”. It indicates the total amount of funds that each financial institution owns. It can increase thanks to deposits and interests paid on the loans. Its value can be changed by the user, using the slider “available_funds_microcredit”, with range 0-1000.

- “**microcredit_on?**”. It is equal to “true” if the financial institution provides microcredit loans to the poor, and to “false” otherwise.

- “**loan_financial_institution**”. It is the maximum amount of money for each loan. If the switcher “microcredit” is off, it is set equal to zero, otherwise its value can be changed by the user, using the slider “credit_limit_microcredit”, with range 0-20.

- “**microcredit_interest_rate**”. It is the interest rate charged by the financial institution on loans. If the switcher “microcredit” is off, it is set equal to zero, otherwise its value can be changed by the user, using the slider “m_interest_rate”, with range 0-1.

These characteristics are reported in Figure 3, which show how financial institutions look like in our model. The related code procedure is reported below:

```
to setup-financial_institutions
create-financial_institution number_of_financial_institutions
[set shape "building institution"
setxy random-xcor random-ycor
set funds_financial_institution available_funds_microcredit
ifelse microcredit
[set microcredit_on? true
set loan_financial_institution credit_limit_microcredit
set microcredit_interest_rate m_interest_rate]
[set microcredit_on? false
set loan_financial_institution 0
set microcredit_interest_rate 0]
```

At the end of each "setup" procedure, we ask to financial_institutions, local_moneylenders, persons, and ordinary_enterprises respectively, to execute the following commands in order to ensure we start with only one turtle per patch:

```
let empty-patches neighbors with [not any? turtles-here]
if any? empty-patches [
let target one-of empty-patches
face target
move-to target]
end
```

Thus, we define the local variables "empty-patches", as the neighbouring patches without any turtles on them. If there are any empty patches, one of them is picked randomly and the turtle is asked to move onto its centre. In this way, each turtle moves at least 1, but it may move an indefinitely large distance until an empty patch is reached.

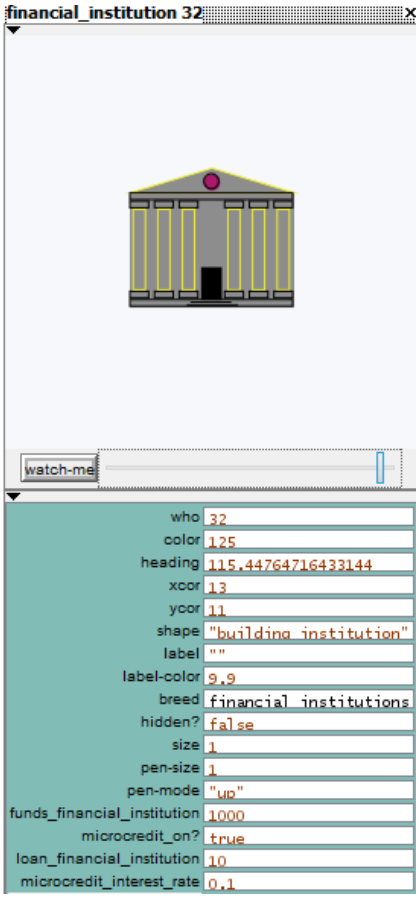


Figure 19: Inspection of a generic financial institution. All financial institutions are endowed with a set of built-in turtle variables, such as the ID number, the colour, the coordinates, the shape, the size, and then the four variables we have previously defined.

3.4.2 Local Moneylenders

The number of local money lenders is chosen through the slider "number_of_local_moneylenders". Similarly to financial institutions, they are characterized by the following attributes:

- "**funds_local_moneylender**". It indicates the total amount of funds that each local moneylender owns. It can increase thanks to the interests paid on the loans. Its value can be set using the slider "available_funds_lml", with range 0-100.

- "**loan_local_moneylender**". It is the maximum amount of each local moneylender's loan. Given the smaller scale of the typical moneylender, the amount of each loan is set at half of that from the financial institution.

- "**interest_rate_local_moneylenders**". It is the interest rate charged by the local moneylenders. The user can establish its value by using the slider "lml_interest_rate", with range 0-1. As we have highlighted in Chapter 1, interest rates charged by local lenders are usually usurious, above 40%, i.e. much higher than those charged by financial institutions.

These characteristics are reported in Figure 4, which show how local moneylenders look like in our model. The related code procedure is reported below:

```
to setup-local_moneylenders
create-local_moneylenders number_of_local_moneylenders
[setxy random-xcor random-ycor
set shape "person soldier"
set size 1.5
set funds_local_moneylenders available_funds_lml
set loan_local_moneylenders credit_limit_microcredit / 2
set interest_rate_local_moneylenders lml_interest_rate
let empty-patches neighbors with [not any? turtles-here]
if any? empty-patches [
let target one-of empty-patches
face target
move-to target]]
end
```

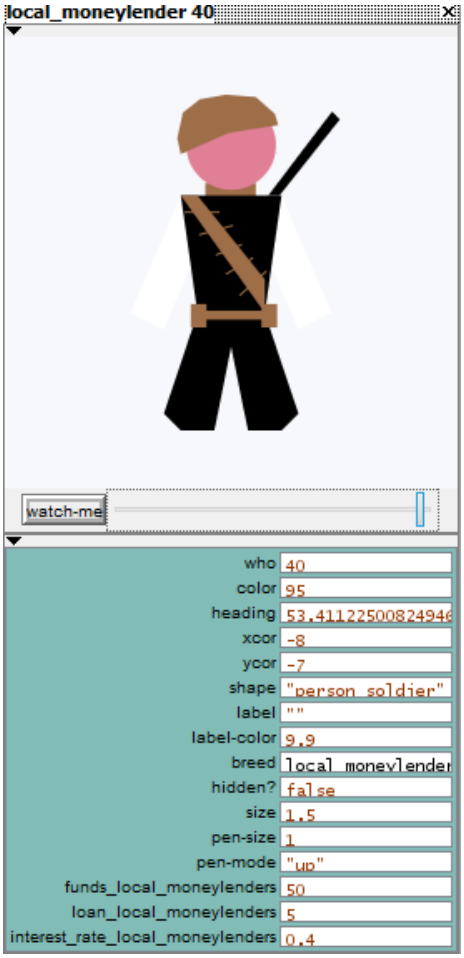


Figure 20: Inspection of one generic local moneylender. All local moneylenders are endowed with a set of built-in turtle variables, such as the ID number, the colour, the coordinates, the shape, the size, and then the four variables we have previously defined.

3.4.3 Persons

The number of persons can be decided by the user through the slider "number_of_persons". We have attributed them the following characteristics:

- "**income**". Each person is endowed with an initial level of income. It is a Poisson-distributed random integer with a mean of 15. In fact, since we are considering an abstract developing country, we have made the plausible assumption that income distribution is more skewed towards the poor.

- "**socioeconomic_status**". Depending on the initial income level and the poverty threshold, which is determined by the slider "poverty_threshold", we divide the breed

"persons" in two categories: if the income level is lower or equal than the threshold, then we assign to the variable "socioeconomic_status" the name "poor", and the name "wealthy" otherwise. As far as the poverty threshold is concerned, we know that, in the real world, its definition is different depending on whether we are considering absolute poverty or relative poverty. In fact, for the former the poverty line is the same for all countries (In October 2015, World Bank updated it to US $1.90 per day), for the latter it can vary across countries because it is the median income. In our simulation, if we consider a poverty threshold of around 15, we can think of it as a poverty line for relative poverty (since the median of a random Poisson variable with mean 15 is 15.332). Thus, we can think that we are analysing income inequality between rural and urban people in an abstract developing country. However, we can change the value of the slider, considering a lower or a higher level for the poverty threshold, just to change the relative dimensions of the poor group and the wealthy group. In order to differentiate visually poor and wealthy people we give to the former the shape "person farmer" with red clothes and to the latter the shape "person service" with green clothes. They are illustrated in Figure 5. Among wealthy people, we have evidenced "village leaders", illustrated in Figure 7, giving them the shape of "person business". We will talk about them more thoroughly in the following section, concerning the network of enterprises.

- "**gender**". In order to allow the user to determine the proportion of male and female in the model, we define a local variable "x" as a random floating point number greater than or equal to zero but strictly less than one. If x is lower or equal to the value of the slider "gender_persons" with range 0-1, we assign to the variable "gender" the name "Female", and the name "Male" otherwise. Thus, the lower the value we choose for the slider, the higher the number of female in the simulation.

- "**entrepreneurial_attitude**". We assume that the entrepreneurial attitude of a male is higher than the one of a female. The reason is that, as the research on women entrepreneurs highlights, they enjoy a relatively low level of education and skill training in developing countries. This, combined with a lack of career guidance, generally seems to limit their access to business development services (Kitching and Woldie, 2004; Davis, 2012). In our model, we capture this aspect by considering that, due to their lower level of entrepreneurial attitude, women are more likely to face difficulties in

accessing microcredit loans. Thus, the "entrepreneurial_attitude" for a man is drawn from the normal distribution N (4, 15), while that for a woman is drawn from N (3, 1). While the average "entrepreneurial_attitude" of a male is higher than that of a female, the variance of "entrepreneurial_attitude" for a male is larger than that of a female, since female borrowers are considered more reliable than male borrowers by financial institutions.

- "**information_status**". It is a binary variable, equal to 1 if the person is informed about microcredit loans and 0 otherwise. When the "setup" button is pressed, all persons have "information_status" equal to zero, except "village leaders", provided that the switcher "microcredit" is on. We will explain this passage in more detail in the following section focused on the network of persons.

- "**threshold_for_becoming_informed**". If the switcher "microcredit" is on, we define this variable as a random floating point number greater or equal to zero but strictly less than one, representing the limit of getting into the informed state. Each person has a different threshold for passing from the uninformed state to the informed state, concerning microcredit loans. If the switcher "microcredit" is off, this variable is equal to zero.

- "**probability_of_becoming_informed".** When the "setup" button is pressed, it is equal to zero. If the switcher "microcredit" is on, then the probability of becoming informed is computed for each individual when the "go" button is pressed. We will explain in more detail the computation of this probability when introducing the procedure "spread_information".

- "**deposits**". It is the amount of money that wealthy people deposit in the nearest financial institution.

- "**debt_financial_institution**". It is the amount of debt the poor owes to the financial institution. We assume that each poor can ask for only one loan, and that this amount is sufficient for the poor to start a microenterprise. When the "setup" button is pressed, the amount of debt starts off as zero, since nobody is a borrower at the beginning. When the

"go" button is pressed, if the switcher "microcredit" is on, it becomes positive if the poor obtains a loan from the financial institution.

- "**debt_local_moneylender".** It is the amount of debt the poor owes to the local moneylender. We assume that this amount is equal to 1/2 the amount of credit the financial institution provides, and that each poor can ask for only one loan. At the beginning of the simulation it is equal to zero. When the "go" button is pressed, it becomes positive if the poor obtains a loan from the local moneylenders.

- "**gifts_strong_ties**". It is the amount of gifts the poor receives from her strong ties, i.e. relatives and friends. We assume that the amount of each gift is equal to 1/3 the amount of credit the financial institution provides, and that the poor can receive more than one gifts at the same time. When the "setup" button is pressed, this variable is equal to zero, as the model starts running, it may become positive if certain conditions are satisfied.

- "**total_informal_credit**". This variable sums the amounts of the variables "gifts_strong_ties" and "debt_local_moneylenders". If the total amount of informal credit is at least equal to the amount of formal credit each financial institution provides, then the poor can starts a microenterprise.

- "**borrower_fi?**". This variable is equal to "true" if the poor obtains a loan from the financial institution and to "false" otherwise.

- "**myfi**". It reports the name of the financial institution the poor owes the debt to. At the beginning of the simulation it is equal to "nobody".

- "**repay_fi?**". It is equal to "true" if the poor has paid the financial institution back and to "false" otherwise.

- "**borrower_lml?**". This variable is equal to "true" if the poor obtains a loan from the local moneylender and to "false" otherwise.

- "**mylml**". It reports the name of the local moneylender the poor owes the debt to. At the beginning of the simulation it is equal to "nobody".

- "**repay_lml?**". It is equal to "true" if the poor has paid the local moneylenders back and to "false" otherwise.

- "**gift_receiver?**". It is equal to "true" if the poor has received a gift from a relative or friend and to "false" otherwise.

- "**microenterprise**". It is equal to "true" if the poor starts a microenterprise. If this is the case, the poor assumes the shape of a factory. When the "setup" button" is pressed, there are no microenterprises.

- "**sector**". It indicates the sector in which the microenterprise is specialized. When the "setup" button is pressed, this variable is equal to "none".

- "**mypartner**". It reports the name of the individual with whom the poor starts a microenterprise. At the beginning of the simulation, it is equal to "nobody" for all persons. We will explain the conditions under which a poor may find a partner when we introduce the "borrow_microcredit" procedure.

- "**increase_in_household_income**". It takes a value greater than zero whenever the poor starts a microenterprise and reinvest part of the money earned from production in her household.

- "**bought_innovative_product?**". It is equal to "true" if the wealthy or poor person buys an innovative product either from an ordinary enterprise or from a microenterprise, and to "false" otherwise.

The variables "ethics_and_social_responsibility" and "social_weighted_impact" will be described when we introduce the procedure "compute_social_impact". These variables take a value greater than zero only when the microenterprise is created and it becomes part of a network of enterprises.

Once the poor starts a microenterprise, she can become part of a network of enterprises (we will talk about this later on). Thus, there are some variables which are common to

the ones ordinary enterprises own, and thus will be defined when the breed "ordinary_enterprises" is presented. The variables are: "enterprise_have_links?", "final_products", "seller?", "sold_products", "money_from_production", "signal_of_failure", "fail_enterpriseT?", "fail_intermediate_producer?",enterprise_betweenness_value", "enterprise_eigenvector_value", "enterprise_closeness_value", and "final_product_innovativeness".

Finally, the variables "person_betweenness_value", "number_of_strong _ties","number_of_weak_ties","number_of_informed_strong_ties" and "number_of_informed_weak_ties" will be defined in the following section, focused on the network of persons.

The related code procedure is reported below.

```
to setup-persons
create-persons number_of_persons [
setxy random-xcor random-ycor
set income random-poisson 15
ifelse income <= poverty_threshold
[set social status "Poor"
set shape "person farmer"
set size 1.5]
[set social status "Wealthy"
set shape "person business"
set size 1.5]
let x random-float 1
ifelse x <= gender_persons
[set gender "Female"
set entrepreneurial_attitude random-normal 3 1]
[set gender "Male"
set entrepreneurial_attitude random-normal 4 15]
set information_status 0
if microcredit [set thresholf_for_becoming_informed random-float 1]
set deposits 0
set debt_financial_institutions 0
```

```
set debt_local_moneylender 0
set gifts_strong_ties 0
set total_informal_credit (debt_local_moneylender + gifts_strong_ties)
set borrower_fi? false
set myfi nobody
set repay_fi? false
set borrower_lml? false
set mylml nobody
set repay_lml? false
set gift_receiver? false
set microenterprise false
set sector "none"
set mypartner nobody
set ethics_and_social_responsibility 0
set social_weighted_impact 0
set increase_in_household_income 0
set initialxcor xcor
set initialycor ycor
set enterprise_have_links? false
set final_products 0
set seller? false
set sold_products 0
set money_from_production 0
set signal_of_failure 0
set fail_enterpriseT? false
set fail_intermediate_producer? false
set enterprise_betweenness_value 0
set enterprise_eigenvector_value 0
set enterprise_closeness_value 0
set final_product_innovativeness 0
set bought_innovative_product? false
let empty-patches neighbors with [not any? turtles-here]
if any? empty-patches
```

```
[let target one-of empty-patches
face target
move-to target]]
end
```

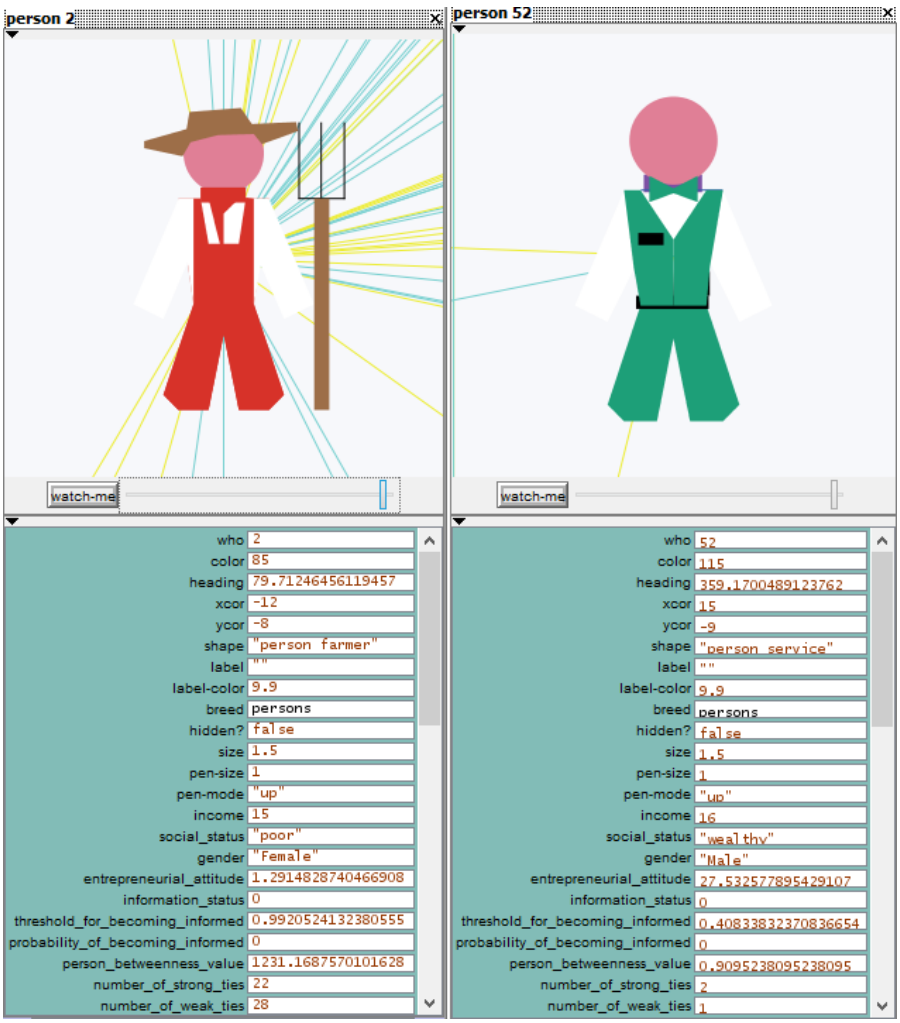


Figure 21: Inspection of a generic poor and wealthy person. All persons are endowed with a set of built-in turtle variables, such as the ID number, the colour, the direction the person is facing and the coordinates (which change once persons start to move), the shape, the size, and then all the variables we have previously defined. For instance, person 2 has a poor social status since her wealth level is equal to 15 and we are setting the "poverty_threshold" at 15. She is a female, her entrepreneurial attitude is quite law (1.29), she is not informed about microcredit and her threshold to pass from the uninformed to the informed state is very high (0.99). She has 22 strong ties, 28 weak ties and her betweenness in the network of persons is extremely high (1231.17). Person 52 is wealthy since his income is equal to 16, he is a male, his entrepreneurial activity is high (27.53), his information threshold is 0.41, he only has 2 strong ties and 1 weak tie and his betweenness is almost 1.

3.4.3.1 Network of Persons

In our model, we consider two types of networks: a network of persons and a network of enterprises. The main difference among the two is that the first one is randomly generated when the "setup" button is pressed, while the second one is created tick by tick after the "go" button is pressed.

In order to describe the network of persons, we need to introduce the concept of "link". Links are a particular type of agents. They are characterized by a head and a tail (respectively labelled as "end1" and "end2"). We have created two different types of links which identify the links in the network of persons and in the network of enterprises respectively.

```
undirected-link-breed [P-P_links P-P_link]
directed-link-breed [B-B_links B-B_link]
```

"B-B_links represent business-to-business connections and we will discuss about them later on. Now, let's focus on "P-P_links", which represent person-to-person connections. They are randomly created when the "setup" button is pressed. The nature of these links is undirected since we think that the direction of the link is not useful in this context. They have two attributes:

- "**connection_strength**". This variable determines whether a link between two persons exists. Referring to Epstein (1996), a link exists if and only if the connection strength is greater than a certain threshold. We define this variable as a random floating point value greater than or equal to zero but strictly less than one. It can be interpreted as a person's willingness to engage in an interpersonal tie, either a weak or a strong tie. If its value is lower than "connection_strength_threshold", which is determined by a slider with range 0-1, than the link is absent. The reason is that the tie has not substantial significance, i.e. the interaction is negligible (for instance a "nodding" relationship among people living in the same village). Thus, the user can vary the size of the network: if the threshold is law, the network will be very dense, otherwise it will have a lower number of links.

- “**weight**”. This variable allows differentiating between the two fundamental types of ties: weak ties and strong ties. According to Granovetter (1973), the former are tenuous or even random relationships with individuals in distant networks, the latter are more stable, frequent and intimate relationships between members of the same network. He defines a tie and its strength as, "a combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie." Thus, in our model we establish that if the “weight” of a link is high, it means that the amount of time, emotional intensity, interpersonal influence, intimacy and reciprocity characterizing the link is high. As the previous attribute, we define it as as a random floating point value greater than or equal to zero but strictly less than one. If it is higher than the value of the slider “weight_threshold”, having range 0-1, than the link is a strong tie, otherwise the link is a weak tie. In order to identify them, we set the colour of strong links to yellow and the colour of weak links to bright blue. Strong ties include family and close friends, weak ties include acquaintances.

Figure 6 provides a graphical representation of what we have just said about “P-P_links”:

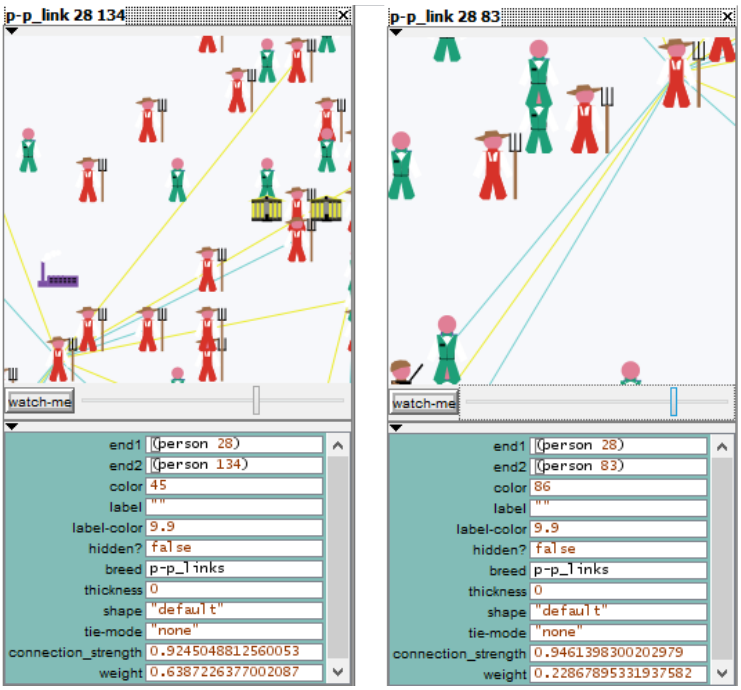


Figure 22: Inspection of two generic P-P links. Considering a value of 0.9 for “connection_strength_threshold” and a value of 0.6 for “weight_threshold”, poor person 28 has a strong tie with another poor, person 134 (on the left), and a weak tie with a wealthy person, person 83 (on the right). Note that we do not assign any value to the built-in link variables “thickness” and “tie-mode”.

Now we can define the following variables owned by all persons:

- "**person_betweenness_value**". This variable indicates the betweenness centrality of each person. In general, the betweenness centrality of a turtle is computed by taking every other possible pairs of turtles and by calculating, for each pair, the proportion of shortest paths between members of the pair that passes through the current turtle. The betweenness centrality of a turtle is the sum of these.

  This measure is crucial to define "village leaders", which are wealthy people having a high level of betweenness (Banerjee et al., 2013). In particular, we define a slider "leaders_betweenness_threshold" through which the user can fix the level of betweenness above which a wealthy individual is considered a leader (in this way the user can vary the number of village leaders in the simulation). An interesting implication of this setting could be the following: in a society where all individuals are well-connected, the betweenness is very low and thus no leaders emerge, i.e. we would have a perfectly democratic society.

  If microcredit is present, as in the model of microcredit for rural household introduced in Chapter 1, the role of village leaders is crucial. However, we take a different perspective: village leaders do not provide information to the financial institutions and do not provide loans to the poor, but they are the injection points for microcredit since they are the first ones to be informed about it and they start the word-of-mouth process. Thus, at the beginning of the simulation, if the switcher "microcredit" is on, only village leaders are informed.

- "**number_of_strong_ties**". This variable counts the number of strong ties each individual has.

- "**number_of_weak_ties**". This variable counts the number of weak ties each individual has.

- "**number_of_informed_strong_ties**". If microcredit is present, it indicates the number of strong connections with village leaders each person has.

- "**number_of_informed_weak_ties**". If microcredit is present, it indicates the number of weak connections with village leaders each person has.

The associated procedure is presented below.

```
to setup-network-of-persons
ask persons [create-P-P_links-with other persons
ask P-P_links [set connection_strength random-float 1
ifelse connection_strength >= connection_strength_threshold
[show-link] [die]
set weight random-float 1
ifelse weight >= weight_threshold [set color 45]
[set color 86]]]
nw:set-context persons P-P_links
show map sort nw:get-context
ask persons[
set person_betweenness_value nw:betweenness-centrality
if (person_betweenness_value > leaders_betweenness_threshold and
socioeconomic_status = "wealthy")[set shape "person business" set size
1.5
set socioeconomic_status "village leaders"
if microcredit [set information_status 1

set threshold_for_becoming_informed 0
ask my-P-P_links [if color = 45 [ask other-end [ set
number_of_informed_strong_ties number_of_informed_strong_ties + 1]]

if color = 86 [ask other-end [ set number_of_informed_weak_ties
number_of_informed_weak_ties + 1]]]]]

set number_of_strong_ties count my-P-P_links with [color = 45]
set number_of_weak_ties count my-P-P_links with [color = 86]
if microcredit [set total-informed count persons with
[information_status = 1]

set total-uninformed count persons with [information_status = 0]]]
end
```

Figure 23: Inspection of a generic village leader in presence of microcredit. We can observe the built-in turtle variables as well as the variables previously defined. Note that, for village leaders, the "threshold_for_becoming_informed" and the "probability_of_becoming_informed" are both zero since the individual is already informed. The betweenness of this individual is very high (369.5), far higher than the threshold "leaders_betweenness_threshold" which was set to 30.

3.4.4 Ordinary_enterprises

The number of ordinary enterprises can be chosen by the slider "number_of_ordinary_enterprises". They own the following variables, which are the same as the ones owned by all poor people who start a microenterprise:

- "**sector**". It indicates the sector each ordinary enterprise is specialized in. The type of sector is indicated with a number randomly determined. Indeed, the variable is equal to "1 + random number_of_sectors", where "number_of_sectors" is a value determined

through a slider, and putting “random” in front of “number_of_sectors” reports a random integer greater than or equal to zero but strictly less than the value of the slider. Since we are summing 1 to it, then sector numbers starts from 1.

Pressing the button “layoutCircle_enterprises_bySector” it is possible to display ordinary enterprises and microenterprises (if present) in a circle centred on the patch at the centre of the view with radius 12, ordered by sector number, which is reported as label. Figure 8 depicts the result of pressing this button. The related code is as follows:

```
to layoutCircle_enterprises_bySector
let enterprises (turtle-set (ordinary_enterprises) (persons with
[shape = "factory" and enterprise_have_links? = true]))
ask enterprises [set label sector
set label-color black]
layout-circle sort-on [sector] enterprises 12
end
```

- “**initialxcor**” and “**initialycor**” simply copy the values of the current x and y coordinates of the enterprise. They are used when the buttons “layoutCircle_enterprises_bySector” and “layoutCircle_enterprises_byBetweenness” are used, in order to display enterprises back to their initial position.

- “**enterprise_have_links?**”. It is equal to “true” if the enterprise is connected with other enterprises and to “false” otherwise.

- “**final_products**”. These are the products that are made at the end of the production process, ready for sale.

- “**seller?”.** It is equal to “true” if the enterprise has sold one final product and to “false” otherwise.

- “**sold_products**”. It indicates the total number of products each enterprise has sold.

- “**money_from_production**”. It indicates the amount of money earned from selling final products.

- "**fail_enterpriseT?**". It is equal to "true" if the last enterprise of a productive chain has failed and to "false" otherwise.

- "**signal_of_failure**". It indicates the total number of signals of failure each enterprise involved in some intermediate steps of some productive chains receives from the last enterprise of the chain. Indeed, every time the last producer fails, a signal of failure is sent to all the intermediate enterprises.

- "**fail_intermediate_producer?**". If the number of signals of failure each intermediate enterprise receives is greater than the value of the slider "threshold_for_failure", then the intermediate enterprise fails as well. Thus this variable becomes equal to "true", otherwise it remains equal to "false".

- "**enterprise_betweenness_value**". It indicates the betweenness centrality (previously defined) of each enterprise.

- "**enterprise_eigenvector_value**". It denotes the eigenvector centrality of each enterprise. This measure can be considered as the amount of influence a node has on a network. Basically, turtles that are connected to many other turtles which in turn are well-connected (and so on) have a higher eigenvector centrality value. Due to normalization, he highest possible value is 1.

- "**enterprise_closeness_value**". It specifies the closeness centrality of each enterprise. This measure is defined as the inverse of the average of the distances of one turtle to all other turtles. If a turtle is isolated than the closeness centrality would be zero.

- "**final_product_innovativeness**". It is equal to 1 if the final product is an innovative product and to zero otherwise. Thus, if there aren't any innovative products, we make the hypothesis that products satisfy the preferences of consumers, so they are willing to buy them and they are homogeneous. This means that each product cannot be distinguished from competing products from different ordinary enterprises or microenterprises. In other words, all products have essentially the same physical characteristics and quality. One product can easily be substituted for the other. Then, given that all products serve exactly the same purpose, the only difference would be

price. In the real world, this hypothesis is reasonable when considering agricultural products, metal and energy-based commodities.

In contrast, if there are some innovative products, we have heterogeneous products, i.e. products that are readily distinguishable from competing products and cannot be easily substituted for one another. The buyer has a preference for innovative products: the greater the number of innovative products she buys, the greater her satisfaction.

The associated code procedure is presented below:

```
to setup-ordinary_enterprises
create-ordinary_enterprises number_of_ordinary_enterprises
[setxy random-xcor random-ycor
set shape "factory"
set color violet
set size 1.5
set sector ( 1 + random number_of_sectors )
set initialxcor xcor
set initialycor ycor
set enterprise_have_links? false
set final_products 0
set seller? false
set sold_products 0
set money_from_production 0
set fail_enterpriseT? false
set signal_of_failure 0
set fail_intermediate_producer? false
set enterprise_betweenness_value 0
set enterprise_eigenvector_value 0
set enterprise_closeness_value 0
set final_product_innovativeness 0
let empty-patches neighbors with [not any? turtles-here]
if any? empty-patches [let target one-of empty-patches
```

```
face target
move-to target]]
end
```

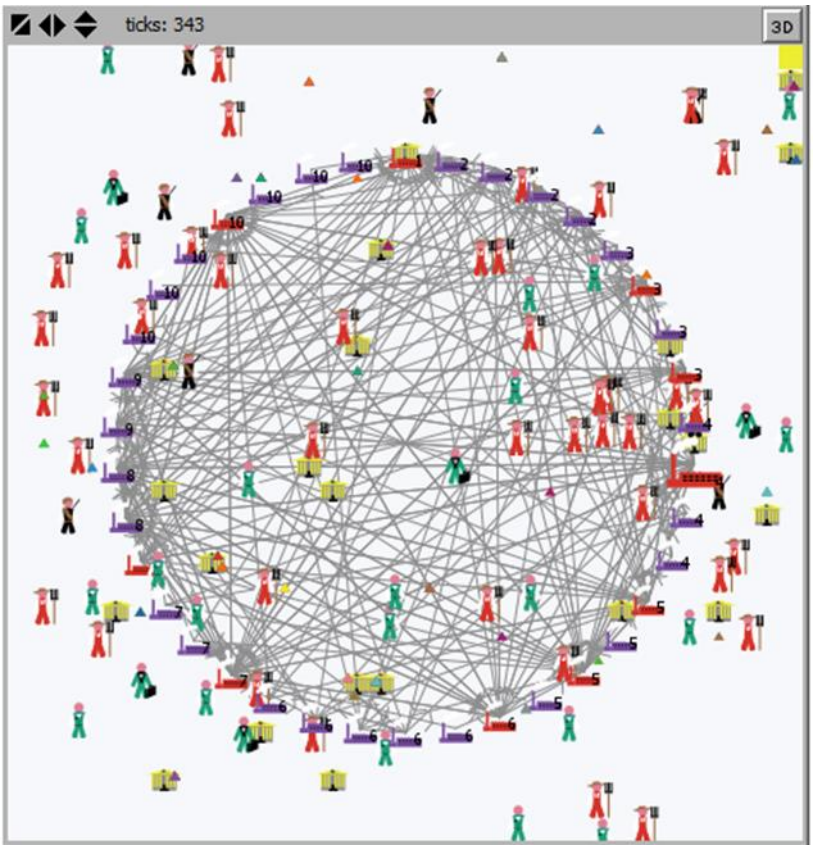


Figure 24: View of the model after pressing the button "layoutCircle_enterprises_bySector", after 343 ticks, considering a value for the slider "number_of_sectors" equal to 10. Red factories are microenterprises while violet factories are ordinary enterprises.

3.4.5 Orders

This variable defines the demand or orders expressed by the market about goods to be produced. We will talk about orders more thoroughly in the following section, when we introduce the "go" procedure "create_orders". For the moment, we describe the variables they own:

- "**recipe**". This is the crucial variable which determines the emergence of the network of enterprises. Each recipe takes the form of a list which collects all the steps that are necessary to realize a final product demanded by the market. The product moves from

one production unit to another according to the specific problem solving skills of each unit, creating a network among production units. In fact, as we previously said by defining the variable "sector", ordinary enterprises and microenterprises (if present) are specialized in executing different steps of each recipe.

- "**recipelength**". It is a variable that indicates the number of steps each recipe is made of. The user can influence this variable through the slider "recipe_length". In fact "recipelength" is equal to "1 + random number_of_sectors".

- "**producers**". This variable is a list which collects all the names of the agents that have implemented a certain step of a recipe, except the last one.

- "**enterpriseT-1**". It reports the name of the enterprise that has executed the penultimate step of a recipe.

- "**enterpriseT**". It reports the name of the enterprise that has executed the last step of a recipe and has produced the final product.

3.5 THE RULES

After having described the environment and the agents of our model, we can now focus on the rules, i.e. the set of commands which determine the agents' behaviour. These commands start operating once the "go" button, illustrated in Figure 10, is pressed by the user.

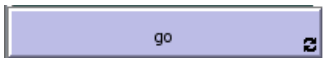


Figure 25: By pressing the "setup" button on the interface, the user allows the creation of the environment and of the agents. Note that this is a "forever" button (as the symbol in the bottom right corner indicates), meaning that it does the actions over and over again, until the user presses the button again and stops the action.

Let's now introduce the main procedures of our model.

3.5.1 To create_orders

At each tick, a certain number of orders is generated, thus we have a continuous flow of orders. The user can decide the number of orders to be created through a slider called "number_of_orders". However, in order not to have a too thick network, it is better to consider a limited number of orders. We give them a triangular shape and, once they are created, we store them in the up right corner of the view (patch sixteen sixteen). In what follows we illustrate the related code procedure and a generic inspection of an order (Figure 11).

```
to create_orders
create-orders number_of_orders [set shape "triangle"
set size 0.5
setxy 16 16
set enterpriseT nobody
set enterpriseT-1 nobody
set recipe []
set producers []
set recipelength (1 + random recipe_length)
repeat recipelength
[set recipe lput (1 + random number_of_sectors) recipe]]
output-print (word number_of_orders "order(s) generated")
end
```

Note that "enterpriseT", "enterpriseT-1" and "producers" will be different from "nobody" and the empty list respectively once the procedure "produce", described later on, starts running.

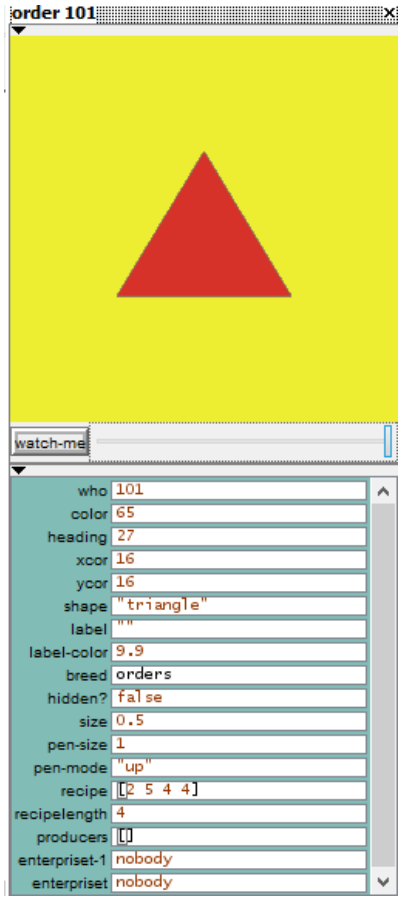


Figure 26: Inspection of a generic order, stored in patch sixteen, sixteen.

3.5.2 To move_persons

Both poor and wealthy people start moving randomly throughout the space. The related code procedure is presented below. Note that once a poor person starts a microenterprise (i.e., the variable “microenterprise” turns true) and assumes the shape of a factory, she does not move randomly anymore.

```
to move_persons
ask persons with [microenterprise = false] [
lt random 360
forward 2]]
end
```

3.5.3 To deposit

Wealthy people deposit an amount of money equal to a fraction of their wealth, say 10%. They choose to deposit this sum in the nearest financial institution. We have made the plausible assumption that poor people do not make deposits in the bank. The associated procedure is as follows:

```
to deposit
ask persons with [socioeconomic_status = "wealthy”][
let my_fi one-of financial_institutions in-radius 0.5
if my_fi != nobody [set myfi my_fi
let my_deposit (income * 0.1)
set deposits (deposits + my_deposit)
ask myfi [
set funds_financial_institution (funds_financial_institution + my_deposit)]]]
end
```

3.5.4 To spread_information_microcredit

We want to consider the effect of the spread of information about microcredit loans through the social network on their diffusion. In order to do this, we make reference to the literature. Abhijit Banerjee et al. (2013) collected network data based on a survey conducted in 43 Indian villages (in Karnataka state) who received loans by a microfinance institution, called Bharatha Swamuktki Samsthe (BSS). In order to detect the factors that influence the decision of applying for a microfinance loan, they distinguished between:

(i) Information passing. Individuals must be informed about the product before they can adopt it, and information can be transmitted both by those who decide to participate in microfinance and those who do not.

(ii) Endorsement effects. The decisions of informed individuals to adopt the product might be directly influenced by their neighbours’ participation decisions.

In their model, each node represents a household, which is the proper unit for microfinance, and the main steps they followed are:

(i) The microfinance institution holds a private meeting to inform a set of "leaders", i.e. highly connected individuals within the village (such as teachers, shopkeepers, savings group leaders) and asks them to diffuse information about the loans in the village. These first-informed individuals play a key role in the development of the diffusion model since they represent the injection points for microfinance in the village. Therefore, network distance to them represents a proxy to measure access to information about microfinance.

(ii) This initial set of informed households decides whether or not to participate.

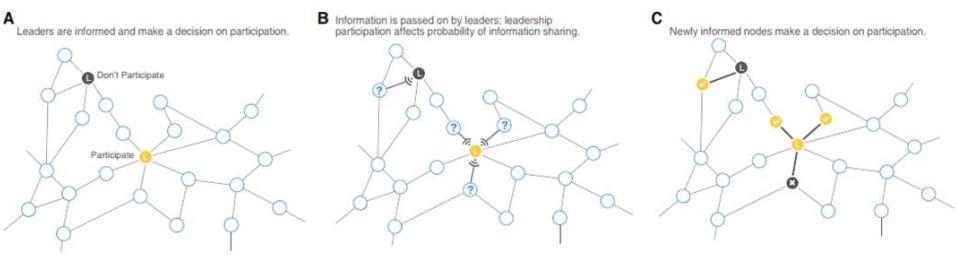
(iii) In each following period, households that have been informed in preceding periods transmit information to their neighbours, independently, with probability q^P if they are participants and with probability q^N if they are nonparticipants.

(iv) Newly informed households decide whether or not to participate. Their decision of applying for a microfinance loan might be influenced by their own characteristics and their neighbours' decisions.

(v) The process has finite horizon: it ends after *T* periods of information passing.

Figure 1 gives a glimpse of this model of diffusion on a network:

A. A set of leaders is informed and decide whether to participate or not.
B. Informed leaders stochastically transmit information to their neighbours; those who have participated are more likely to share information.
C. Newly informed nodes decide whether to participate or not.
D. Newly informed nodes transmit information further, with a higher probability if they have participated.
E. Another round of newly informed nodes decides whether to participate or not.



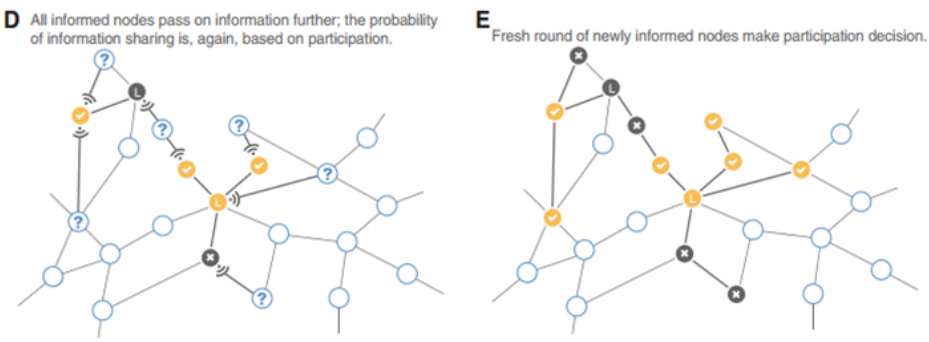


Figure 27: Diffusion of information and participation, Abhijit Banerjee et al. (2013).

In order to build the model, Abhijit Banerjee et al. (2013) used a logistic function:

$$\log\left(\frac{p_{it}}{1-p_{it}}\right) = X_i'\beta + \lambda F_{it}$$

where *pit* represents the probability of participating of an informed individual, which is a function of the individual's characteristics *Xt*, and *Fit* is the ratio of the number of individuals who participate in microfinance to the number of *i*'s neighbours who transmitted information to *i* about the program. As far as the coefficients are concerned, λ represents the change in the log-odds ratio of participation of household *i* which participates because of a variation in the fraction of participating neighbours who transmitted information to *i*, and β represents a vector of coefficients which show how the log-odds ratio changes as characteristics *Xi* change. Using the method of simulated moments, Abhijit Banerjee et al. (2013) first focused on the information model, setting λ equal to zero, and then on the information model with endorsement effects (where individuals potentially take into consideration the participation decisions of their informed neighbours), estimating λ.

Figure 2 shows the results of the estimation. In the first row, the estimated parameters of the information model are presented. The probability that an informed household who has participated transmits information to a neighbour, q^P, is equal to 0.350; while the probability that an informed household who has not participated transmits information to a neighbour, q^N, is equal to 0.050. However, even if nonparticipants transmit information at a lower rate than participants, they represent a larger fraction of villagers with respect to participants and therefore they play a key role in the diffusion process. In the second row, the estimated parameters of the information model with endorsement effects are presented.

There is no evidence for a positive endorsement effect: the participation decision of informed households does not significantly depend on whether their neighbours have participated in microfinance.

	q^N	q^P	λ	$q^N - q^P$
Information model	0.050 (0.01)	0.350 (0.124)	—	−0.300 (0.126)
Information model with endorsement	0.050 (0.007)	0.500 (0.234)	−0.200 (0.146)	−0.450 (0.234)

Figure 28: Estimated parameters, Abhijit Banerjee et al. (2013).

Moreover, Abhijit Banerjee et al. (2013) measured the potential influence or effectiveness of the first-informed individuals with regard to spreading information, which they called communication centrality. According to their analysis, communication centrality of the injection points is better than other ordinary measures of centrality in terms of prediction of microfinance participation. However, since this measure is difficult to compute, they introduced a proxy for it, which they called diffusion centrality, strongly correlated to communication centrality.

The diffusion centrality of a node *i* in a network can be defined as the expected total number of times that the set of all nodes is informed.

$$DC(\mathbf{g}; q, T) := \left[\sum_{t=1}^{T} (q\mathbf{g})^t \right] \cdot 1$$

where **g** is the adjacency matrix, q is the probability that a node transmits information to each neighbour, T is the number of iterations. If T=1, diffusion centrality is proportional to degree centrality, if $T \rightarrow \infty$, it is proportional to other measures of centrality such as Katz-Bonacich centrality and eigenvector centrality, and if T has a value in-between, diffusion centrality differs from other measures.

Figure 3 illustrates the results of four regressions of microfinance participation at village-level on several measures of centrality of leaders (degree centrality, eigenvector centrality, Katz-Bonacich centrality, betweenness centrality, decay centrality, or closeness centrality), after introducing some village-level controls. In particular, the first regression stresses that communication centrality is strongly correlated with eventual

participation and this holds also in the third regression, when controlling for other measures of centrality.

Centrality measure	Regression			
	1	2	3	4
Communication	0.766 (0.335)		0.713 (0.428)	
Diffusion		0.022 (0.007)		0.018 (0.009)
Degree			−0.005 (0.006)	−0.003 (0.006)
Eigenvector			3.572 (2.330)	3.692 (2.265)
Betweenness			1.709 (1.776)	1.710 (1.687)
Katz-Bonacich			−0.072 (0.070)	−0.106 (0.063)
Decay			0.032 (0.047)	0.034 (0.045)
Closeness			−1.077 (1.551)	−0.891 (1.496)
R^2	0.406	0.442	0.530	0.515

Figure 29: Microfinance participation versus measures of centrality of leaders, Abhijit Banerjee et al. (2013).

Figure 4 shows that village-level microfinance participation is significantly correlated with communication centrality, degree centrality, and diffusion centrality. It highlights that diffusion centrality predicts eventual participation equally well as communication centrality.

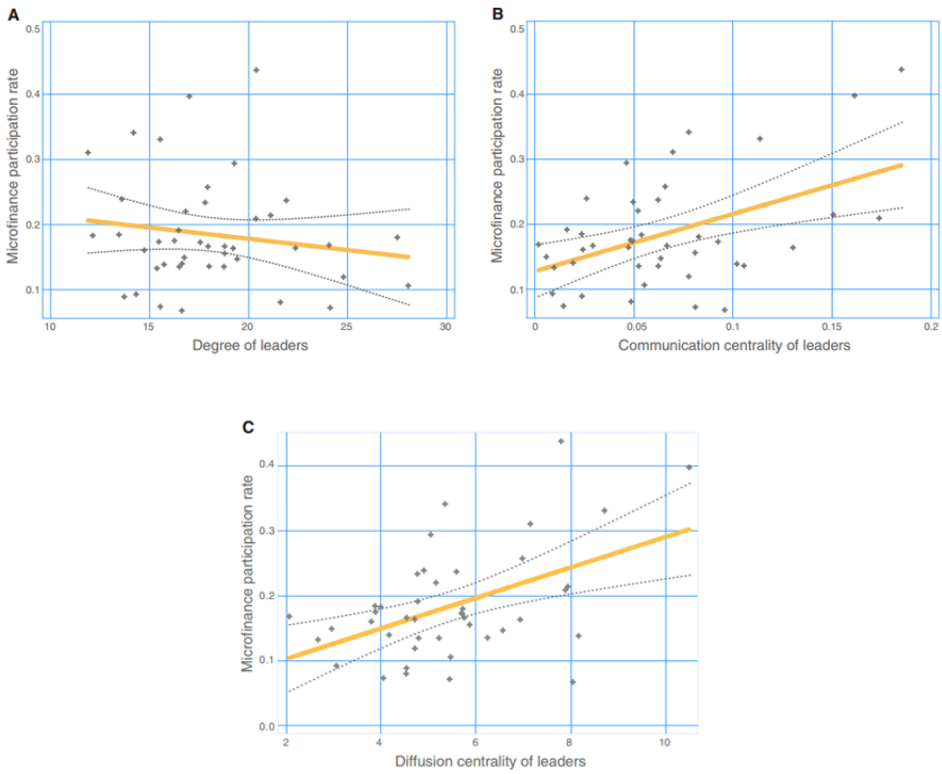


Figure 30: Abhijit Banerjee et al. (2013).

To sum up, the main results founded by Abhijit Banerjee et al. (2013) are:

- Microfinance participants are seven times as likely to transmit information compared to informed nonparticipants, but information transmitted by nonparticipants still accounts for roughly one-third of eventual participation.
- Once information passing is considered, it does not matter whether the information was transmitted by a participant or a nonparticipant, i.e. an informed household is not more likely to participate if its informed neighbours participate (no endorsement effect).
- Communication centrality, applied to the set of injection points in a village, predicts microfinance participation significantly better than other standard network measures of centrality.
- Diffusion centrality, a proxy measure for communication centrality, is strongly correlated with communication centrality.

Relying on the results of Abhijit Banerjee et al. (2013), in our model we do not consider the endorsement effect and we focus on the information passing effect only. As previously said, at the beginning of the simulation only village leaders are informed. When they start informing other people, a word-of-mouth (w-o-m) mechanism takes place.

According to Rogers (1995), even if there are stronger information flows within strong ties, weak ties play a key role in spreading information by word-of-mouth, in particular about innovations. Referring to Goldenberg et al. (2001), the probability of a member to move from the uninformed state to the informed one is:

$$p(t) = (1 - (1 - \alpha)(1 - \beta_w)^j (1 - \beta_s)^m)$$

where

- α is the probability of an uninformed individual becoming informed through advertising, which is assumed to be lower than the effect of w-o-m (Buttle, 1998).
- β_s is the probability of an uninformed individual of becoming informed thanks to an informed individual which is connected to her by a strong tie. According to Brown and Reingen (1987), β_s is greater than β_w.
- β_w is the probability of an uninformed individual of becoming informed thanks to an informed individual which is connected to her by a weak tie.
- j is the number of "informed" weak ties, i.e. the number of informed individuals which are not directly connected to the highlighted individual.

- m is the number of "informed" strong ties, i.e. the number of informed individuals which are directly connected to the highlighted individual.

In our model, we use the same formula by defining α as the effect of propaganda. We define the following sliders, with a range equal to 0-0.5:

- effect_of_propaganda
- effect_of_strong_ties
- effect_of_weak_ties

The individual needs to have a probability greater or equal to her individual "threshold_for_becoming_informed" (defined in section 3.4.3) in order to become informed. The introduction of information is of utter importance for our model since if voters are rational and informed about microcredit, they should ask for a loan with a higher probability. In order to capture this increase in probability, we create a local variable x, defined as a random floating point value greater than or equal to zero but strictly less than one. The poor person will ask for a loan whenever x is lower or equal than the value determined by the slider "probability_of_asking_for_loan".
The code procedure is as follows:

```
to spread_information_microcredit
if microcredit [
ask persons [
set number_of_informed_strong_ties count my-P-P_links with [color = 45
and [information_status] of other-end = 1]
set number_of_informed_weak_ties count my-P-P_links with [color = 86
and [information_status] of other-end = 1]
set probability_of_becoming_informed (1 - ((1 - effect_of_propaganda)*
((1 - effect_strong_ties) ^ number_of_informed_weak_ties) * ((1 -
effect_of_weak_ties) ^ number_of_informed_strong ties)))
if probability_of_becoming_informed >= threshold_for_becoming_informed
[set information_status 1]
set total-informed count persons with [information_status = 1]
set total-uninformed count persons with [information_status = 0]
]]
end
```

Note that the procedure “spread_information_microcredit” is activated only if the switcher “microcredit” is on, the same goes for the procedure “borrow_microcredit”.

3.5.5 To borrow_microcredit

In our model, we make the hypothesis that poor people use all their initial income to satisfy their living needs (such as food, clothing, health care and shelter), thus, in order to start a microenterprise, they need to borrow money.

We are going to restrict our attention on microcredit loans with the objective of helping the poor start their own microenterprise. For this reason, the key that determines the likelihood for a poor of receiving a microcredit loan is that the level of entrepreneurial and innovative attitude of the poor is higher than a certain threshold. Thus, the financial institution evaluates the quality of the entrepreneurial project and provides loans only to poor people with promising business plans. The threshold can be changed by the user, through the slider “threshold_for_fi_loan”, so that the user can create a world where is less or more difficult to access microcredit. An evolution of the model could be considering also the possibility that microcredit loans are used for personal consumption (nutrition, education, health, and so on).

We assume that the amount of money provided to the poor by the financial institution (determined by the slider “credit_limit_microcredit”) is sufficient to start a microenterprise, which is capable to execute a certain step of a recipe.

Therefore, each poor asks for only one loan (i.e. if borrower_mfi? = false); in particular she chooses one among the nearest financial institutions which can provide the loan. An evolution of the model could include the possibility for the poor of asking for more loans.

With the microcredit loan, the poor can hire labour force, buy raw materials and other inputs of production. In our model, we capture this simply by transforming the shape of the poor person in the shape of a factory with red colour. A future development of the model could include the existence of raw material suppliers and the possibility to hire those poor people who fail to get a loan and have very low wealth levels: they may give up the idea of starting a microenterprise and decide to be employees. Thus, a further implication of microcredit could be the fact that, by allowing the creation of

microenterprises, employment among poor people can rise, providing them an alternative way to escape poverty.

After microcredit is given to the poor, the amount of funds available to the financial institution will be decreased and the debts of the poor will be increased. Note that we define the variable “debt_financial_institution” as including also the interests the poor has to pay on the borrowed sum. The variable “ethics_and_social_responsability” will be described when we introduce the procedure “compute_social_impact”.

The associated code procedure is reported below.

```
to borrow_microcredit
if microcredit [let x random-float 1
ask persons with [(socioeconomic_status = "poor") and
(information_status = 1) and (mypartner = nobody)]
[if (x <= probability_of_asking_for_microcredit) and
(entrepreneurial_attitude >= threshold_for_fi_loan) and (borrower_fi?
= false) [let my_fi one-of financial_institutions with
[funds_financial_institution > credit_limit_microcredit] in-radius 1
if my_fi != nobody [set myfi my_fi
ask my_fi [set funds_financial_institution
(funds_financial_institution - loan_financial_institution)]
set debt_financial_institution ((debt_financial_institution +
credit_limit_microcredit) * ( m_interest_rate + 1))
set shape "factory"
set color red
set size 1.5
set borrower_fi? true
set microenterprise true
set sector ( 1 + random number_of_sectors )
ifelse gender = "Male"
[set ethics_and_social_responsibility random-float 5 +
ethics_and_CSR_of_microenterprises]
[set ethics_and_social_responsibility 5 +
ethics_and_CSR_of_microenterprises]]]
```

If the entrepreneurial attitude of the poor is not greater than the “threshold_for_fi_loan”, her project is considered unpromising and she needs to find a partner. If she finds an individual under the same situation and if the sum of their entrepreneurial attitudes is higher than the “threshold_for_joint_loan”, they will form a group and jointly apply for

microcredit. In particular, each one of the two individuals reports the name of the other in the variable “mypartner” and they split the debt equally (so that each one has to repay only half of it). As shown in Figure 16, the connection between them is highlighted by a red P-P_link. Only one of the two partners creates the microenterprise, which assumes a bigger size, and they split the money earned from production equally. The related code procedure is reported below.

```
if (x <= probability_of_asking_for_microcredit) and
(entrepreneurial_attitude < threshold_for_fi_loan) and (borrower_fi? =
false)[let my_fi one-of financial_institutions with
[funds_financial_institution > credit_limit_microcredit] in-radius 1

let my_partner one-of other persons with [(socioeconomic_status =
"poor") and (information_status = 1) and (entrepreneurial_attitude <
threshold_for_fi_loan) and (borrower_fi? = false) and (borrower_lml? =
false) and (mypartner = nobody)] in-radius 0.5

if my_partner != nobody and my_fi != nobody [

if entrepreneurial_attitude + [entrepreneurial_attitude] of my_partner
> threshold_for_joint_loan [

create-P-P_link-with my_partner [set color red]

ask my_partner [set mypartner myself

set borrower_fi? true

set myfi my_fi

set debt_financial_institution ((debt_financial_institution +
(credit_limit_microcredit / 2))* ( m_interest_rate + 1))]

set mypartner my_partner

set myfi my_fi

ask my_fi [set funds_financial_institution
(funds_financial_institution - loan_financial_institution)]

set shape "factory"

set color red

set size 2.5
```

```
set debt_financial_institution ((debt_financial_institution +
(credit_limit_microcredit / 2)) * ( m_interest_rate + 1))

set borrower_fi? true

set microenterprise true

set sector ( 1 + random number_of_sectors )

ifelse gender = "Male"

[set ethics_and_social_responsibility random-float 5 +
ethics_and_CSR_of_microenterprises]

[set ethics_and_social_responsibility  5 +
ethics_and_CSR_of_microenterprises]]]]]]

end
```

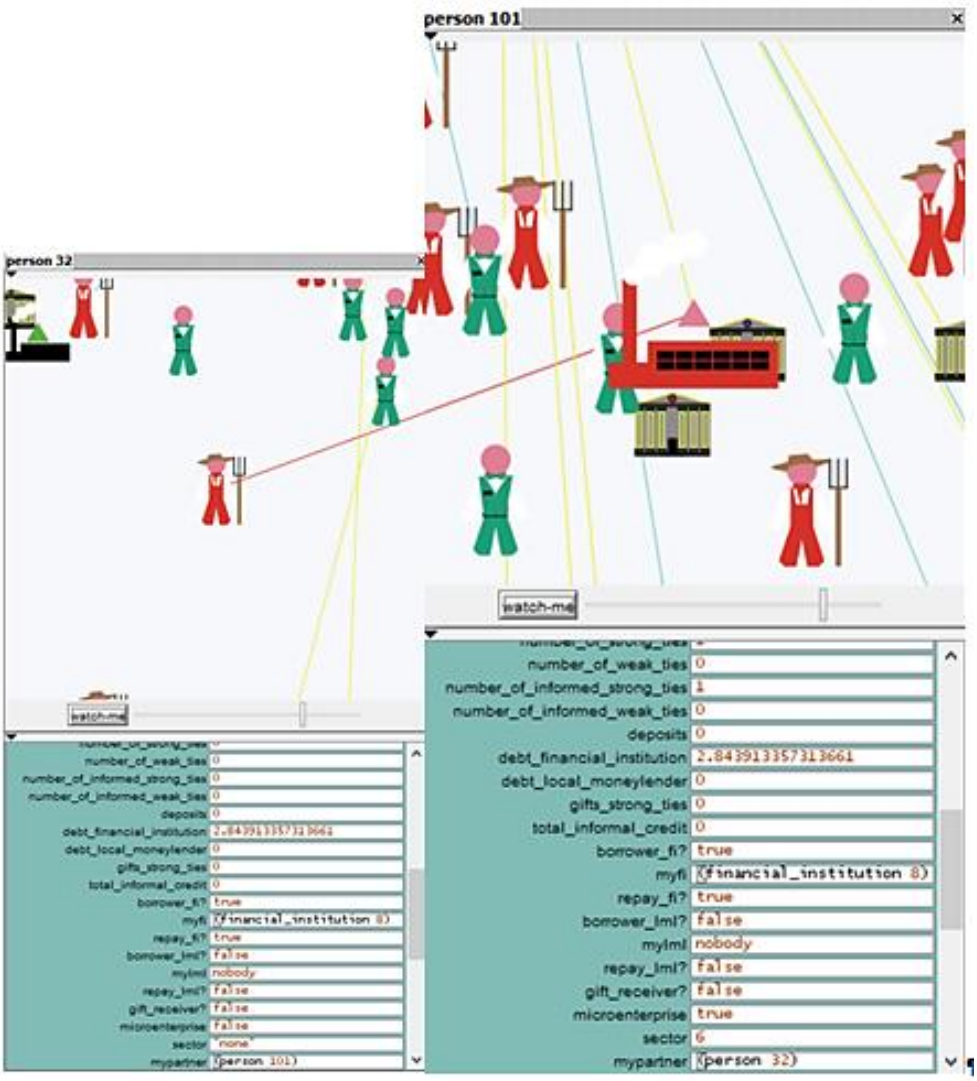


Figure 31: Inspection of two generic partners. Partner 32 has an entrepreneurial attitude of 6.81, and partner 101 of 3.76. Alone, they could not apply for microcredit since the slider "threshold_for_fi_loan" was set at 7. However, the sum of their entrepreneurial levels (10.57) is higher than the "threshold_for_joint_loan", set at 9, thus they can apply for microcredit jointly. They split the debt equally towards the same financial institution (8), and they also start repaying a part of it.

3.5.6 To receive_gifts

In addition to microcredit it is important to look at other informal sources of credit since we believe that any investigation on microcredit should take these other credit-sources into account. As we have said in Chapter 1, microcredit and informal lending (which includes transactions between relatives or friends and local moneylenders) are imperfect substitutes. However, there is strong evidence that, when microcredit is absent, the

probability of relying on informal lending increases notably. With this procedure, we focus on credit coming from friends and relatives; we consider it as a form of gift, given that, very often in developing countries, it is not paid back. As we have seen in Chapter 1, in China, informal sources of credit are very much dependent on an individual guanxi. This is why we now take into consideration P-P links and, in particular, strong ties. We make the hypothesis that strong ties can lend 1/3 of the amount that financial institutions lend to the poor.

Thus, if microcredit is present (the switcher "microcredit" is on), poor people will rely on gifts from strong ties with a law probability, which can be fix with the slider "receiving_gifts_with_m". The associated code procedure is as follows:

```
to receive_gifts
let x random-float 1
ifelse microcredit [if x <= receiving_gifts_with_m [ask P-P_links with
[weight = "strong_tie"] [if end1 = one-of persons with
[socioeconomic_status = "poor"] and [income] of end1 < [income] of
end2 and [income] of end2 >= credit_Limit_microcredit / 3[ask end1
[set income (income + credit_limit_microcredit / 3)
set gift_receiver? true
set gifts_strong_ties gifts_strong_ties + credit_limit_microcredit /
3]
ask end2 [set income (income - credit_limit_microcredit / 3)]]
if end2 = one-of persons with [socioeconomic_status = "poor"] and
[income] of end2 < [income] of end1 and [income] of end1 >=
credit_Limit_microcredit / 3 [ask end1 [set income (income -
credit_limit_microcredit / 3)]
ask end2 [set income (income + credit_limit_microcredit / 3)
set gift_receiver? true
set gifts_strong_ties gifts_strong_ties + credit_limit_microcredit /
3]]]]]
```

If instead, microcredit is absent (the switcher "microcredit" is off), poor people rely on gifts from strong ties with a high probability, which can be fixed with the slider

“receiving_gifts_without_m”. The second part of the “ifelse” command is reported below:

```
[if x <= receiving_gifts_without_m [ask P-P_links with [weight =
"strong_tie"] [if  end1 = one-of persons with [socioeconomic_status =
"poor"] and [income] of end1 < [income] of end2 and [income] of end2
>= credit_Limit_microcredit / 3[ask end1 [set income (income +
credit_limit_microcredit / 3)

set gift_receiver? true

set gifts_strong_ties gifts_strong_ties + credit_limit_microcredit /
3]

ask end2 [set income (income - credit_limit_microcredit / 3)]]

if end2 = one-of persons with [socioeconomic_status = "poor"] and
[income] of end2 < [income] of end1 and [income] of end1 >=
credit_Limit_microcredit / 3 [ask end1 [

set income (income - credit_limit_microcredit / 3)]

ask end2 [set income (income + credit_limit_microcredit / 3)

set gift_receiver? true

set gifts_strong_ties gifts_strong_ties + credit_limit_microcredit /
3]]]]]

end
```

3.5.7 To borrow_local_moneylenders

In developing countries, the second most important actor of informal lending is the local moneylender. As we have said in Chapter 1, strong ties crowd out local moneylenders, (since, if a poor has the possibility to rely on strong ties rather than local moneylenders, she will prefer so, given that the latter charge usurious interest rates). We have assumed that local moneylenders can lend 1/2 of the amount lent by financial institutions. As for microcredit loans, we have made the hypothesis that each poor borrows from only one local moneylender (i.e. if borrower_lml? is false).

We have distinguished four situations: the first two are characterized by the presence of microcredit (switcher “microcredit” on), with few and many strong ties respectively,

and the other two are characterized by the absence of microcredit (switcher "microcredit" off), with few and many strong ties respectively.

- **Microcredit on and few strong ties.**

If microcredit is present, but the poor has a low entrepreneurial attitude (i.e. cannot apply for a loan) and she cannot find a partner, than she has to address local moneylenders. If she has a few strong ties (in particular, a number of strong ties lower or equal to the value of the slider "limit_st_for_borrowing_lml"), she will rely on local moneylender with a high probability (fixed by the slider "borrowing_from_lml_with_m&few_st"). The related code is as follows:

```
to borrow_local_moneylenders

let x random-float 1

ifelse microcredit [ask persons with [ (socioeconomic_status = "poor")
and (entrepreneurial_attitude < threshold_for_fi_loan) and (mypartner
!= nobody) and (number_of_strong_ties <= limit_st_for_borrowing_lml)
and (borrower_lml? = false)][if x <= borrowing_from_lml_with_m&few_st
[

let my_lml one-of local_moneylenders with [funds_local_moneylender >=
credit_limit_microcredit / 2] in-radius 1

if my_lml != nobody [

set mylml my_lml

set debt_local_moneylender ((debt_local_moneylender +
credit_limit_microcredit / 2) * (lml_interest_rate + 1 ))

set borrower_lml? true

ask mylml [set funds_local_moneylender (funds_local_moneylender -
credit_limit_microcredit / 2) ]]]]
```

- **Microcredit on and many strong ties.**

If, as in the previous case, the poor cannot access microcredit but has many strong ties (in particular, a number of strong ties greater than the value of the slider

“limit_st_for_borrowing_lml”), she will rely on local moneylender with a lower probability (fixed by the slider “borrowing_from_lml_with_m&many_st”). The related code is as follows:

```
ask persons with [(socioeconomic_status = "poor") and
(entrepreneurial_attitude < threshold_for_fi_loan) and (mypartner !=
nobody) and (number_of_strong_ties > limit_st_for_borrowing_lml) and
(borrower_lml? = false) ][if x <= borrowing_from_lml_with_m&many_st [

let my_lml one-of local_moneylenders with [funds_local_moneylender >=
credit_limit_microcredit / 2] in-radius 1

if my_lml != nobody [

set mylml my_lml

set debt_local_moneylender ((debt_local_moneylender +
credit_limit_microcredit / 2) * (lml_interest_rate + 1 ))

set borrower_lml? true

ask mylml [set funds_local_moneylender (funds_local_moneylender -
credit_limit_microcredit / 2) ]]]]]
```

- **Microcredit off and few strong ties.**

If microcredit is absent and the poor has a few strong ties (in particular, a number of strong ties lower or equal to the value of the slider “limit_st_for_borrowing_lml”), she will rely on local moneylenders with a high probability (fixed by the slider “borrowing_from_lml_without_m&few_st”). The related code is as follows:

```
[ask persons with [(socioeconomic_status = "poor") and
(number_of_strong_ties <= limit_st_for_borrowing_lml ) and
(borrower_lml? = false)][ if x <= borrowing_from_lml_without_m&few_st
[let my_lml one-of local_moneylenders with [funds_local_moneylender >=
credit_limit_microcredit / 2] in-radius 1

if my_lml != nobody [set mylml my_lml

set debt_local_moneylender ((debt_local_moneylender +
credit_limit_microcredit / 2)* (lml_interest_rate + 1 ))
```

```
set borrower_lml? true

ask mylml [set funds_local_moneylender (funds_local_moneylender -
credit_limit_microcredit / 2)]]]]
```

- **Microcredit off and few strong ties.**

Finally, if microcredit is absent but the poor has many strong ties (in particular, a number of strong ties greater than the value of the slider “limit_st_for_borrowing_lml”), she will rely on local moneylenders with a lower probability (fixed by the slider “borrowing_from_lml_without_m&many_st”). The related code is as follows:

```
ask persons with [(socioeconomic_status = "poor") and
(number_of_strong_ties > limit_st_for_borrowing_lml) and
(borrower_lml? = false) ] [if x <=
borrowing_from_lml_without_m&many_st [

let my_lml one-of local_moneylenders with [funds_local_moneylender >=
credit_limit_microcredit / 2] in-radius 1

if my_lml != nobody [

set mylml my_lml

set debt_local_moneylender ((debt_local_moneylender +
credit_limit_microcredit / 2) * (lml_interest_rate + 1 ))

set borrower_lml? true

ask mylml [set funds_local_moneylender (funds_local_moneylender -
credit_limit_microcredit / 2)]]]]]

end
```

3.5.8 To create_microenterprise

We make the hypothesis that if the amount of informal credit is at least equal to the amount of microcredit loans (which is enough to create a microenterprise), the poor

decides to start a microenterprise (if it is lower, the poor use it for consumption and other purposes). The associated code procedure is reported below.

```
to create_microenterprise

ask persons with [socioeconomic_status = "poor" and mypartner =
nobody] [

if total_informal_credit >= credit_limit_microcredit [

set shape "factory"

set color red

set size 1.5

set microenterprise true

set sector (1 + random number_of_sectors)

ifelse gender = "Male"

[set ethics_and_social_responsibility random-float 5 +
ethics_and_CSR_of_microenterprises]

[set ethics_and_social_responsibility 5 +
ethics_and_CSR_of_microenterprises]]]

end
```

Therefore, at each tick we have the development of lending (either informal or formal) which allows poor agents to become entrepreneurs and start production (if credit is enough). Now, it's time to describe the development of production, which allows poor agents to pay back debts.

3.5.9 To-report a_step_forward

As previously said, production happens through the mechanism of the recipes. We now present a reporter procedure according to which, when a step of a recipe is executed (i.e. there is an enterprise capable to execute that step, having the sector number equal to the step of the recipe), that step is cancelled from the list "recipe". Thus, if all the steps of a recipe are executed, the variable "recipe" is equal to an empty list. If this is not the case, i.e. there are still some numbers in the list, it means that there are no enterprises capable

to do certain steps of a recipe required by an order. As a consequence, final products cannot be produced and a structural hole is generated.

```
to-report a_step_forward
let enterprises (turtle-set (ordinary_enterprises) (persons with
[shape = "factory" and enterprise_have_links? = true]))
let step 0
if recipe != [ ][
set step first recipe
if count enterprises with [sector = step] > 0
[set recipe but-first recipe]]
report step
end
```

3.5.10 To produce

As previously said, tick by tick orders are generated, and recipes executed. As ordinary enterprises, each microenterprise is specialized in executing a certain step of a recipe. If there is a microenterprise capable to execute a certain step, then that one will be chosen even if there is an ordinary enterprise capable to do the same step, because the microenterprise is cheaper. Each order moves from the point where it was stored (patch sixteen, sixteen) to the patch of a non-failed enterprise capable to implement the step. We collect in the global variable “list_of_recipe_lengths” the lengths of the recipes of all orders. The first part of the related code procedure is illustrated below, and Figure 17 and 18 provide a graphical representation of it.

```
to produce
set list_of_recipe_lengths [length recipe] of orders
ask orders [let forwardstep a_step_forward
let current_order self
if forwardstep != 0 [
let dest_ordinary_enterprise one-of ordinary_enterprises with [sector
= forwardstep and color != black]
let dest_microenterprise one-of persons with [sector = forwardstep and
color != black]
```

```
ifelse one-of persons with [sector = forwardstep and color != black]
!= nobody [move-to dest_microenterprise
set enterpriseT-1 enterpriseT
set enterpriseT dest_microenterprise
set producers lput enterpriseT producers
set producers remove nobody producers]
[if  dest_ordinary_enterprise != nobody [
move-to dest_ordinary_enterprise
set enterpriseT-1 enterpriseT
set enterpriseT dest_ordinary_enterprise
set producers lput enterpriseT-1 producers
set producers remove nobody producers]]
```

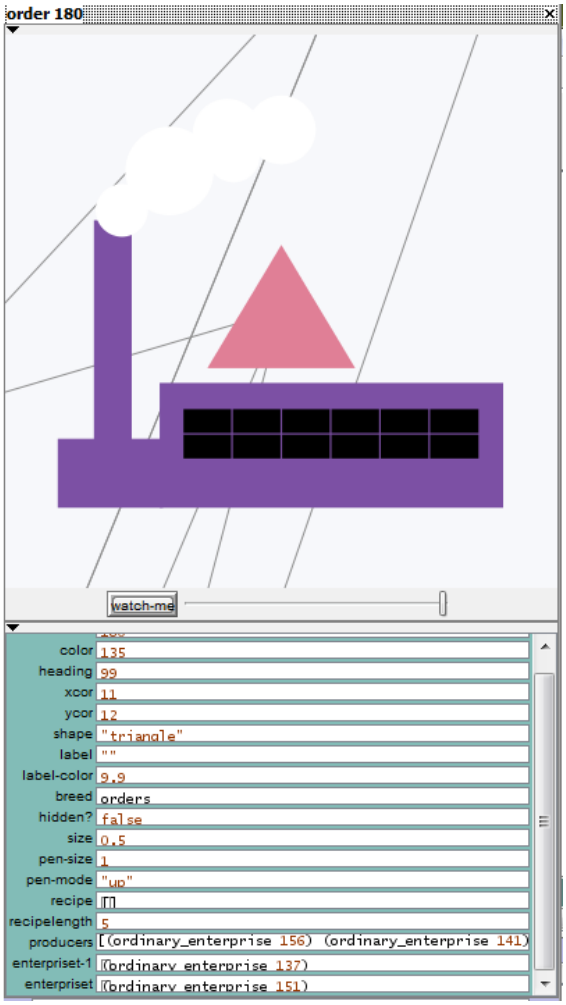


Figure 17: Inspection of a generic order, on the same patch of an ordinary enterprise. Order 180 concerns a final product which, in order to be realized, requires the execution of five passages. The list “recipe” is empty, meaning that all steps have been executed. The variables “enterpriseT-1” and “enterpriseT” reports the name of the penultimate and last producers, respectively. The list “producers” collects all the

enterprises that have executed the five steps: “ordinary_enterprise 156”, “ordinary_enterprise 141”, “ordinary_enterprise 155”, “ordinary_enterprise 137” and “ordinary_enterprise 151”.

Note that, if there is a recipe with just one step, then “enterpriseT-1” will be equal to “nobody”, “enterpriseT” will be equal to the enterprise which completes the unique step of the recipe and the list “producers” will contain nobody. For reasons of convenience, we remove the element nobody from the list producers. This case can be seen in the Figure below.

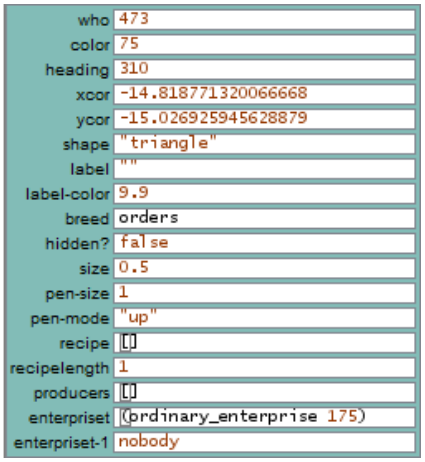


Figura 18: Inspection of a generic order carrying a recipe with just one step.

The second part of the “produce” procedure allows the creation of the second network of our model: the network of enterprises.

3.5.10.1 Network of enterprises

As the program goes by, links among enterprises emerge. As said in section 3.4.3.1, we indicate this kind of links as “B-B links”, i.e. business-to-business connections. The nature of these links is directed since they are created once the productive chain starts and the product moves from one enterprise able to do a certain step of a recipe to another one, able to do the following step. They own two attributes:

- "**quantity**". This variable counts the number of times an order passed through the same link. The link is created only the first time a transit takes place, and then every other transit increases the variable "quantity" by one unit.

- "**relationship_commitment**". As said in Chapter 1, it can be interpreted as the amount of mutual trust, common beliefs, willingness to adopt a risk-taking behaviour and motivation the two parts of links have. It is a random floating point number greater or equal to zero but strictly less than one, randomly assigned to each link. Each time the same link is strengthened by orders passing there, the "relationship_commitment" increases by another random floating point value greater than or equal to zero but strictly less than one. Thus, we do not attribute a constant value to "relationship_commitment" since we want to support a certain degree of variability, which is correlated to the number of cycles we consider in our simulation (since the variance of a random variable uniformly distributed over the interval [0 1] is 1/12, if we consider a link strengthen by 10 orders passing there, the variance of the "relationship_commitment" of that link would be lower, and equal to 10/12). In this way, we capture two phenomena:

  - Once another contact among two agents is established, they might have a new level of relationship commitment, higher or lower than the one characterising the first contact, because some conditions might have change.
  - Agents that have more occasions of contact are likely to have higher levels of relationship commitment.

The related code part is illustrated below and Figure 19 provides a graphical representation of the network.

```
if enterpriseT-1 != nobody and enterpriseT-1 != enterpriseT and
[color] of enterpriseT-1 != black and [color] of enterpriseT != black
[let onelink B-B_link [who] of enterpriseT-1 [who] of enterpriseT
ifelse onelink != nobody [ask onelink [set quantity quantity + 1
set relationship_commitment relationship_commitment + random-float 1]]
[ask [enterpriseT-1] of current_order [
create-B-B_link-to [enterpriseT] of current_order [set quantity 1
set relationship_commitment random-float 1]
```

```
set enterprise_have_links? true]
ask [enterpriseT] of current_order [set enterprise_have_links? true]]]]
```

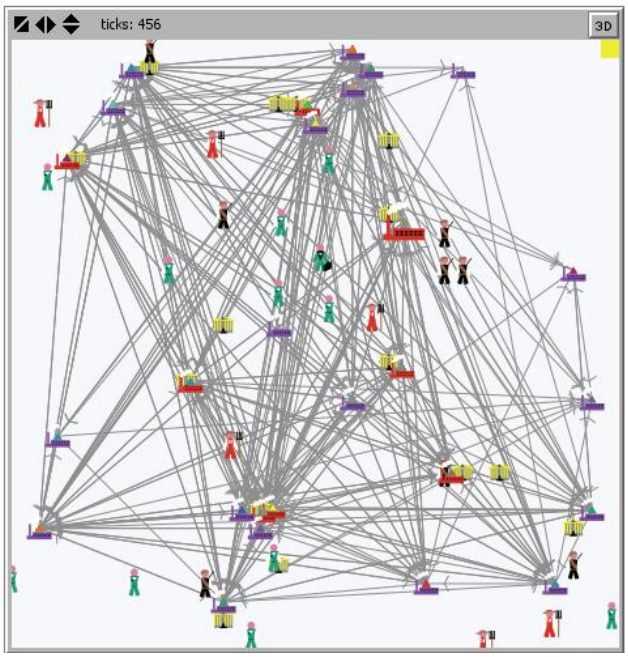


Figure 19: View showing the network of enterprises after 456 ticks.

When a recipe ends (i.e. it is equal to "[]", an empty list), an order is completed and a final product is produced by the last enterprise which participates in the production of that recipe ("enterpriseT"). We ask to that enterprise to increase the variable "final_products" by 1. As previously said, recipes that are not ended represent structural holes. Microcredit, by allowing poor people to create a microenterprise, may help in bridging these structural holes.

Following the interpretation of Burt (1992), enterprises that occupy a position in the network hole are likely to accrue more social capital. In fact, more connected enterprises are crucial for the diffusion of knowledge, thoughts, and choices, fostering creativity. However, as we said in Chapter 1, when we developed the concept of Guanxi, having a huge number of connections is not enough, what matters is the relationship commitment (previously defined). In order to detect the most connected enterprises in our model, we consider the ones that have the "enterprise_eigenvector_value" (previously defined) higher than the "threshold_for_connectedness" (which is a slider with range 0-1). If these enterprises

have also a “relationship_commitment” higher than the value of the slider “threshold_for_commitment”, than they can produce an innovative product.
If the number of finished products reaches a certain threshold, determined by the slider “threshold_for_failure”, then the last agent of the list producers fail, due to overproduction. When a firm fails it stops its activity and it becomes black.
The last part of the “produce” procedure is now presented.

```
if recipe = [] [if enterpriseT != nobody [ask enterpriseT [
ifelse final_products != threshold_for_failure
[set final_products final_products + 1
if enterprise_eigenvector_value != false [
if (enterprise_eigenvector_value > threshold_for_connectedness) and
sum [relationship_commitment] of my-in-B-B_links >
threshold_for_commitment [set final_product_innovativeness 1]]]
[set color black
set fail_enterpriseT? true
stop]]]]]
end
```

3.5.11 To signal_failure&fail_producers

Every time an “enterpriseT” fails, she sends a signal of failure to all the agents that have participated in the production of that product. If the number of signal of failures received by each intermediate producer is greater than the value of “threshold_for_failure”, then it fails as well. The associated code procedure is now shown.

```
to signal_failure&fail_producers
ask orders [if (recipe = [] and producers != [])[
let current_order self
ask [enterpriseT] of current_order [if fail_enterpriseT? = true [
foreach [producers] of current_order [
ask ? [ifelse signal_of_failure != threshold_for_failure
[set signal_of_failure signal_of_failure + 1]
[set color black
Set fail_intermediate_producer? True
```

```
stop]]]]]]]
end
```

3.5.12 To trade

Once they are produced, it is possible to trade final products on the market.

Poor people and wealthy people buy products with a different probability. In order to capture this, we create a local variable x using “let”, and we give it a random floating point value greater than or equal to zero but strictly less than one. At each tick, the probability with which wealthy people buy a product is determined by x <= probability_of_buying_wealthy, which is controlled with a slider. By the same reasoning, the probability with which poor people buy a product is determined by x <= probability_of_buying_poor, which is controlled with a slider. We think that wealthy people are more likely to buy products than poor people, therefore we have set the default values of these two probabilities at 0.9 and 0.1, respectively, but this can be changed by the user.

In the real world, consumers prefer products that offer the most quality, performance, or innovative features. Thus, we make the hypothesis that, if there is an innovative enterprise in a radius determined by the slider “radius_of_sale”, then that one is chosen by consumers, otherwise a traditional enterprise is chosen.

The price of a product is proportional to the number of steps necessary to produce it. If more steps are carried out, we can reasonably think that the product is more elaborated and thus the price is higher. Thus, if for instance there is a recipe made of 2 steps, the price of the final product will be 2, if the steps are 8, the price will be 8. We assume that the price is divided equally among all producers, hence each of them obtains 1. The related code procedure is reported below.

```
to trade
let x random-float 1
ask orders [if recipe = [] [let price 1 * recipelength
let enterprises (turtle-set (ordinary_enterprises) (persons with
[shape = "factory" and enterprise_have_links? = true]))
let innovative_enterpriseT  one-of enterprises with [final_products >
0 and final_product_innovativeness = 1]
ifelse innovative_enterpriseT != nobody [ask innovative_enterpriseT [
```

```
if fail_enterpriseT? = false and fail_intermediate_producer? = false [
let my_wealthy_buyer  one-of persons with [socioeconomic_status =
"wealthy" and income > price ] in-radius radius_of_sale
if my_wealthy_buyer != nobody [if x <= probability_of_buying_wealthy [
set final_products final_products - 1
set sold_products sold_products + 1
set money_from_production  money_from_production + 1
set seller? true
if color != red
[set  money_from_production money_from_production + 1]
if color = red [
ifelse mypartner != nobody
[set money_from_production money_from_production + 0.5
ask mypartner [set money_from_production  money_from_production +
0.5]]
[set money_from_production money_from_production + 1]
if gender = "Female" [set increase_in_household_income
money_invested_in_hh_women * money_from_production]
if gender = "Male" [set increase_in_household_income
money_invested_in_hh_men * money_from_production]]
ask my_wealthy_buyer [set income income -  price
set bought_innovative_product? true ]]]
let my_poor_buyer  one-of persons with [socioeconomic_status = "poor"
and microenterprise = false and income > price] in-radius
radius_of_sale
if my_poor_buyer != nobody [if x <= probability_of_buying_poor [
set final_products final_products - 1
set sold_products sold_products + 1
set money_from_production money_from_production + 1
set seller? true
if color != red
[set  money_from_production money_from_production + 1]
if color = red [ifelse mypartner != nobody
[set money_from_production money_from_production + 0.5
ask mypartner [set money_from_production  money_from_production +
0.5]]
[set money_from_production money_from_production + 1]
if gender = "Female" [set increase_in_household_income
money_invested_in_hh_women * money_from_production]
if gender = "Male" [set increase_in_household_income
money_invested_in_hh_men * money_from_production]]
ask my_poor_buyer [set income income - price
```

```
set bought_innovative_product? True]]]]]
if producers != [] [
if [seller?] of innovative_enterpriseT = true [foreach producers [
ask ? [if fail_intermediate_producer? = false [if color != red
[set  money_from_production money_from_production + 1]
if color = red [ifelse mypartner != nobody
[set money_from_production money_from_production + 0.5
ask mypartner [set money_from_production  money_from_production +
0.5]]
[set money_from_production money_from_production + 1]
if gender = "Female" [set increase_in_household_income
money_invested_in_hh_women * money_from_production]
if gender = "Male" [set increase_in_household_income
money_invested_in_hh_men * money_from_production]]]]]]]]
[ if enterpriseT != nobody [ ask enterpriseT [if (final_products > 0
and fail_enterpriseT? = false and fail_intermediate_producer? = false)
[let my_wealthy_buyer  one-of persons with [socioeconomic_status =
"wealthy" and income > price ] in-radius radius_of_sale
if my_wealthy_buyer != nobody [if x <= probability_of_buying_wealthy [
set final_products final_products - 1
set sold_products sold_products + 1
set seller? true
if color != red
[set money_from_production  money_from_production + 1]
if color = red [ifelse mypartner != nobody
[set money_from_production money_from_production + 0.5
ask mypartner [set money_from_production  money_from_production +
0.5]]
[set money_from_production money_from_production + 1]
if gender = "Female" [set increase_in_household_income
money_invested_in_hh_women * money_from_production]
if gender = "Male" [set increase_in_household_income
money_invested_in_hh_men * money_from_production]]
ask my_wealthy_buyer [set income income - price
set bought_innovative_product? False]]]
let my_poor_buyer  one-of persons with [socioeconomic_status = "poor"
and microenterprise = false and income > price] in-radius
radius_of_sale
if my_poor_buyer != nobody [if x <= probability_of_buying_poor [
set final_products final_products - 1
set sold_products sold_products + 1
set seller? true
```

```
if color != red
[set money_from_production money_from_production + 1]
if color = red [ifelse mypartner != nobody
[set money_from_production money_from_production + 0.5
ask mypartner [set money_from_production  money_from_production +
0.5]]
[set money_from_production money_from_production + 1]
if gender = "Female" [set increase_in_household_income
money_invested_in_hh_women * money_from_production]
if gender = "Male" [set increase_in_household_income
money_invested_in_hh_men * money_from_production]]
ask my_poor_buyer [
set income income - price
set bought_innovative_product? False]]]]]]
if producers != [] [if [seller?] of enterpriseT = true [
foreach producers [ask ? [if fail_intermediate_producer? = false [
if color != red [set  money_from_production money_from_production + 1]
if color = red [ifelse mypartner != nobody
[set money_from_production money_from_production + 0.5
ask mypartner [set money_from_production  money_from_production +
0.5]]
[set money_from_production money_from_production + 1]
if gender = "Female" [set increase_in_household_income
money_invested_in_hh_women * money_from_production]
if gender = "Male" [set increase_in_household_income
money_invested_in_hh_men * money_from_production]]]]]]]]]]
end
```

3.5.13 To repay_fi

Using the profit from sales, the poor can repay the loan to financial institutions. We make the plausible assumption that female repay with a higher probability than male. These probabilities can be decided by the user through the sliders “probability_of_repayment_women” and “probability_of_repayment_men”.

In addition, we assume that at each tick, the poor pays back 1/20 of the money earned from production until the debt is exhausted. If “money_from_production” is zero, than the microenterprise cannot repay neither a small part of the debt. This may happen either because no consumer bought the final product or because the microenterprise is

involved in productive chains which cannot be completed because of the lack of enterprises capable to execute the final steps of the recipes, and thus final products are not produced. The code procedure is reported below.

```
to repay_fi
let x random-float 1
ask persons with [(borrower_fi? = true) and (color != black) and
(money_from_production > 0) and (debt_financial_institution > 0) ] [
if gender = "Female" [if x < probability_of_repayment_women [
ifelse money_from_production / 20 < debt_financial_institution
[let repayment money_from_production / 20
set debt_financial_institution debt_financial_institution - repayment
set money_from_production money_from_production - repayment
set repay_fi? true
ask myfi [set funds_financial_institution funds_financial_institution
+ repayment]]
[let repayment debt_financial_institution
set debt_financial_institution debt_financial_institution - repayment
set money_from_production money_from_production - repayment
set repay_fi? true
ask myfi [
set funds_financial_institution funds_financial_institution +
repayment ]]]]
if gender =  "Male" [
if x < probability_of_repayment_men [
ifelse money_from_production / 20 < debt_financial_institution
[let repayment money_from_production / 20
set debt_financial_institution debt_financial_institution - repayment
set money_from_production money_from_production - repayment
set repay_fi? true
ask myfi [set funds_financial_institution funds_financial_institution
+ repayment]]
[let repayment debt_financial_institution
set debt_financial_institution debt_financial_institution - repayment
set money_from_production money_from_production - repayment
set repay_fi? true
ask myfi [set funds_financial_institution funds_financial_institution
+ repayment]]]]]
end
```

3.5.14 To repay_lml

By the same way explained above, the poor can pay back debts to local moneylenders. The code procedure is presented below.

```
to repay_lml
let x random-float 1
ask persons with [(borrower_lml? = true) and (color != black) and
(money_from_production > 0) and (debt_local_moneylender > 0) ] [
if gender =  "Female" [if x < probability_of_repayment_women [
ifelse money_from_production / 20 < debt_local_moneylender
[let repayment money_from_production / 20
set debt_local_moneylender debt_local_moneylender - repayment
set money_from_production money_from_production - repayment
set repay_lml? true
ask mylml [set funds_local_moneylender funds_local_moneylender +
repayment]]
[let repayment debt_local_moneylender
set debt_local_moneylender debt_local_moneylender - repayment
set money_from_production money_from_production - repayment
set repay_lml? true
ask mylml [set funds_local_moneylender funds_local_moneylender +
repayment]]]]
if gender =  "Male" [if x < probability_of_repayment_men [
ifelse money_from_production / 20 < debt_local_moneylender
[let repayment money_from_production / 20
set debt_local_moneylender debt_local_moneylender - repayment
set money_from_production money_from_production - repayment
set repay_lml? true
ask mylml [set funds_local_moneylender funds_local_moneylender +
repayment]]
[let repayment debt_local_moneylender
set debt_local_moneylender debt_local_moneylender - repayment
set money_from_production money_from_production - repayment
set repay_lml? true
ask mylml [set funds_local_moneylender funds_local_moneylender +
repayment]]]]]
end
```

3.5.15 To update_network_of_enterprises

Differently from the network of persons, the values of betweenness, eigenvector centrality and closeness centrality (previously defined) of the network of enterprises are computed tick by tick, thus we can evaluate the impact of the formation of the network as it emerges. The associated code procedure is as follows:

```
to update_network_of_enterprises
let enterprises (turtle-set (ordinary_enterprises) (persons with
[shape = "factory" and enterprise_have_links? = true]))
nw:set-context enterprises B-B_links
show map sort nw:get-context
ask enterprises [
set enterprise_betweenness_value nw:betweenness-centrality
set enterprise_eigenvector_value nw:eigenvector-centrality
set enterprise_closeness_value nw:closeness-centrality]
end
```

When the model stops, i.e. no further orders are created, pressing the button “betweenness”, it is possible to visualize each node’s betweenness centrality: enterprises with a higher betweenness have a bigger size (as shown in Figure 20).

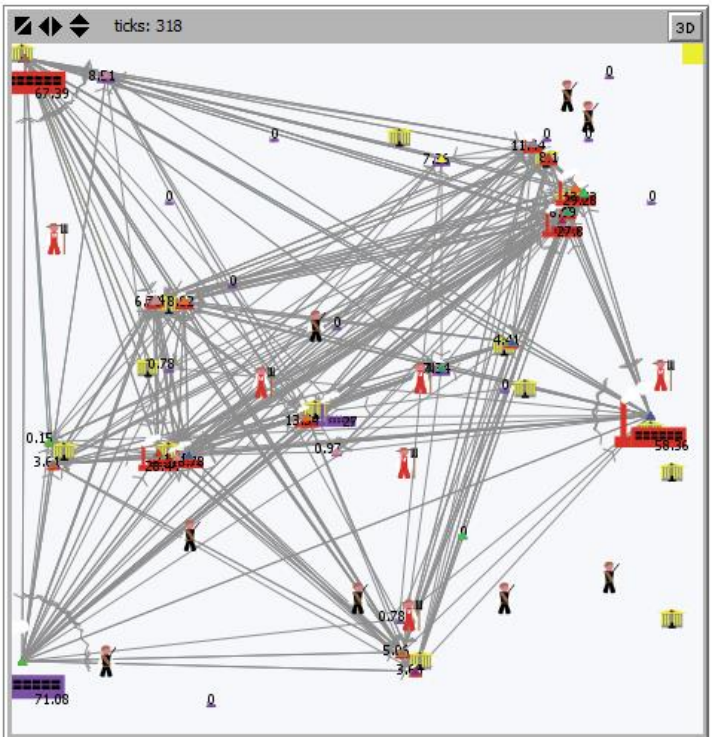


Figura 20:

We recall that the betweenness centrality of a node is the sum of all-pairs shortest paths passing through that node. The presence of a few nodes with high betweenness centrality is an indicator of the fragility of the network. Indeed, in an equilibrated network, there should be many connections between all nodes.

In Figure 21, we report the same network as Figure 20, showing the enterprises in a circle in order to better identify the key nodes.

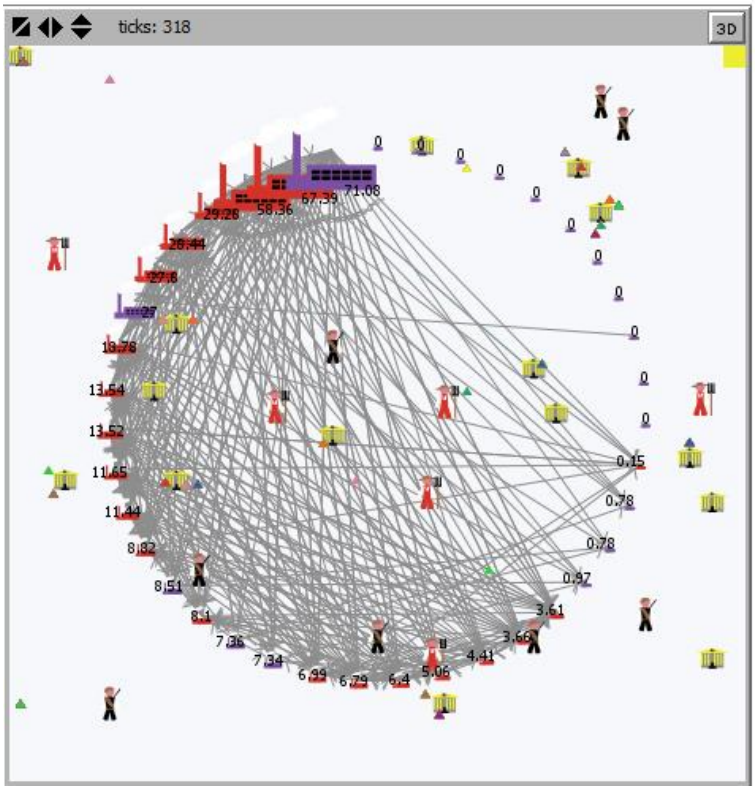


Figura 21:

Note that at the end of the simulation, it may be useful to press the button "delete_links", in order to have a clearer vision of the interface.

3.5.16 To compute_social_impact

Now we are interested in answering the following question: How much microenterprises influence the society? What does the society gain if microenterprises develop?

In order to do so, we have defined two variables:

- "ethics_and_social_responsibility". It is the sum of a random floating point number greater than or equal to 0 and strictly less than 5 and a value determined by a slider called "ethics_and_CSR_of_microenterprises". Thus, the user can partially determine the level of ethics of microenterprises. For instance, if the user sets the value 0 for the slider, then the level of ethics of microenterprises will be low, if instead the user chooses a value of 3, then all microenterprises will have a level of ethics of at least 3.

- “social_weighted_impact”. It is the product of “ethics_and_social_responsibility” and the betweenness value of each enterprise. In fact, it can be considered as a measure of how important the enterprise is for the society. Our claim is that the network has an amplificatory effect, enhancing the ethic role each microenterprise can play through connections with other enterprises. Thus, firms with a higher betweenness will have a deeper impact on the society. The referred code procedure is reported below.

```
to compute_social_impact
ask persons with [shape = "factory" and enterprise_have_links? = true]
[set social_weighted_impact ethics_and_social_responsibility *
enterprise_betweenness_value]
end
```

3.5.17 To direct_selling_microenterprise

There might be some enterprises which are not linked to any other enterprise in the network. Thus, as far as microenterprises are concerned, we can distinguish between the case of simple production and the case of structured production. In the case of simple production, microenterprises directly sell the product to the consumer, and they earn less than linked microenterprises (0.5 instead that 1). The associated code procedure is illustrated below.

```
to direct_selling_microenterprise
let x random-float 1
ask persons with [shape = "factory"] [if ticks = 365 * periods [
if enterprise_have_links? = false [let my_buyer one-of persons with
[microenterprise = false] in-radius radius_of_sale
if my_buyer = one-of persons with [socioeconomic_status = "wealthy"] [
if x <= probability_of_buying_wealthy [set money_from_production
money_from_production + 1
if gender = "Female" [set increase_in_household_income
money_invested_in_hh_women * money_from_production]
if gender = "Male" [set increase_in_household_income
money_invested_in_hh_men * money_from_production]
```

```
set seller? true
ask my_buyer [set income income - 1
set bought_innovative_product? False]]]
if my_buyer = one-of persons with [socioeconomic_status = "poor"] [
if x <= probability_of_buying_poor [
set money_from_production money_from_production + 0.5
set seller? true
if gender = "Female" [set increase_in_household_income
money_invested_in_hh_women * money_from_production]
if gender = "Male" [set increase_in_household_income
money_invested_in_hh_men * money_from_production]
ask my_buyer [set income income - 0.5
set bought_innovative_product? False ]]]]]]
end
```

3.5.18 The Role of Women

We decided to introduce in our model some insights about the crucial role played by women, when microcredit is present. The aspects we consider are the following:

(i) Women are more concerned with social, ethical and environmental considerations in business. In order to capture this, for each microenterprise led by a woman we set the value of the variable "ethics_and_social_responsibility" as "5 + ethics_and_CSR_of_microenterprises" instead of "random-float 5 + ethics_and_CSR_of_microenterprises", where "ethics_and_CSR_of_microenterprises" is a slider with range 0-5.

(ii) Women invest a higher amount of "money_from_production" in their households. This can be set by the user, using the two sliders "money_invested_in_hh_women" and "money_invested_in_hh_men". According to the literature the percentages of reinvestment are 90% for women and 30-40% for men, which are the default values of our sliders. An evolution of the model could include also other variables which represent the fields in which household income is spent, such as nutrition or literacy.

(iii) Women have a higher probability of repayment than men. In order to capture this aspect we consider two sliders "probability_of_repayment_women" and "probability_of_repayment_men".

A further evolution of the model could be introducing the benefits for children: children of employed women could have a better performance in school and a higher life expectancy.

3.6 THE EXPERIMENTS

Now it is time to conduct some experiments using our model, and make some considerations on the results. For each experiment, we highlight our starting assumptions, which are represented by the values attributed to the sliders, and the graphical output, which help us to describe the emergent phenomena. Obviously, a huge number of experiments can be performed; we focus on the ones we think are the most significant. In order to make our experiments replicable, we have introduced the possibility for the user to fix the pseudo-random sequence of number (which is called "seed" in Netlogo terminology), by adding a switcher in the interface, shown in Figure 1.

Figure 32: Switcher allowing the possibility to replicate the experiments starting from the same initial conditions.

For all experiments, we consider a time horizon of 121 ticks which correspond to two years and a few months, given that each tick represents one week. However, the user is free to decide when the model stops running automatically, by changing the value of the variable "periods", determined by the slider "time_span_weeks", ranging from 0 to 1050 (thus the model could keep on running up to 20 years). This is established by the following two lines of code, added to the "setup" and "go" procedures, respectively.

```
set periods time_span_weeks
```

```
if ticks > 7 * periods [stop]
```

3.6.1 Experiments with Microcredit

The first set of experiments will be conducted under the fundamental assumption that financial institutions provide microcredit loans. Then, these experiments will be replicated considering that microcredit is absent. By comparing the results, we are able to provide some conclusions about the role microcredit plays in a developing country.

3.6.1.1 Predominance of Strong Ties and Negligible Propaganda Effect

In order to analyse the role of microcredit in a developing country, we need to focus on the information spreading process since it represents the first fundamental prerequisite for accessing formal credit.

Figures 2, 4, 8, 14 and 16 summarize the main starting assumptions of our simulation. We consider a world with 20 ordinary enterprises, 200 individuals, 20 financial institutions and 10 local moneylenders. By fixing the poverty threshold at 15 (recall that "income" is a Poisson-distributed random variable with mean 15), we are able to generate a scenario where more than 60% of the population has a low socioeconomic status. By fixing the value of the slider "gender_persons" at 0.7, we are able to establish that the number of poor women is higher than the number of poor men. The values of the sliders "connection_strength_threshold" and "weight_threshold" (0.5 and 0.8, respectively) allows us to create a not too thick network of persons characterized by the prevalence of strong ties over weak ties. Moreover, we define "village leaders" as those persons having a high socioeconomic status and a level of betweenness higher than the "leaders_betweenness_threshold" (set at 60). As previously said, "village leaders" are the only ones to be informed about microcredit: thus, when the "setup" button is pressed, there are just two informed agents, and the rest of the population is uninformed. The values of the sliders "effect_of_weak_ties", "effect_of_strong_ties" and "effect_of_propaganda", are set at 0.1, 0.2, and 0.05, respectively.

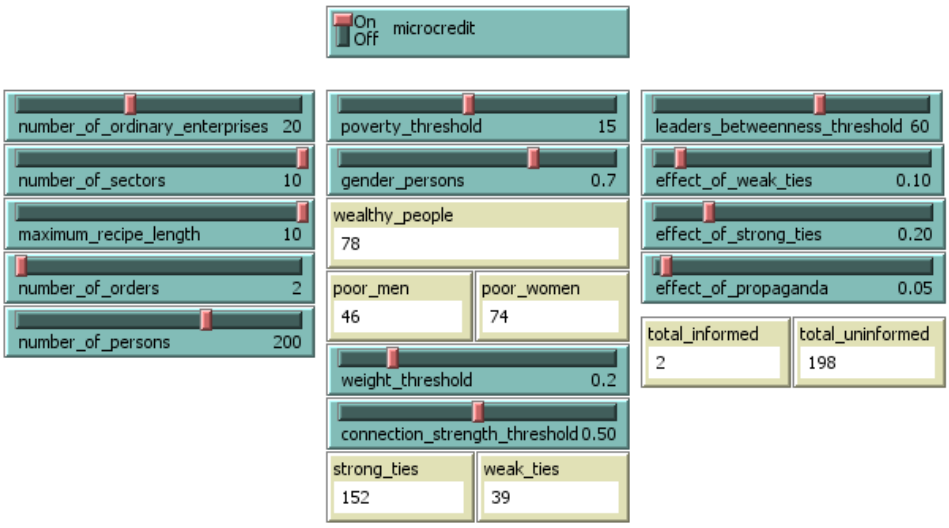


Figure 33: Sliders and monitors, starting conditions.

After generating the world and leaving the program run for 121 ticks, we obtain the following result: as shown in Figure 2, thanks to the world-of-mouth process initiated by the two informed village leaders, 27 individuals become informed. However, there is still a large number of poor which are uninformed.

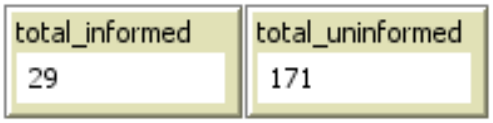


Figure 3: Monitors illustrating the number of informed and uninformed individuals about microcredit, after that the w-o-m process has taken place

By assuming the values shown in Figure 3 for the sliders concerning financial institutions and local moneylenders, we obtain the graphical output shown in Figure 4.

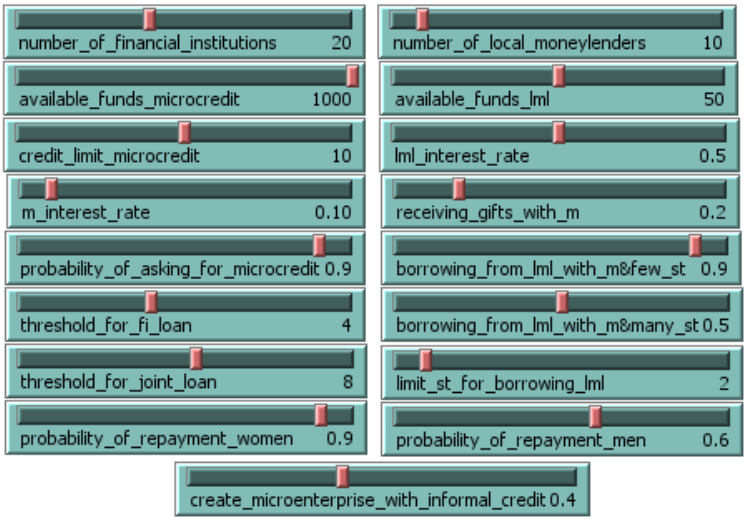


Figure 4: Sliders concerning the variables of financial institutions and local moneylenders, and the probabilities of receiving gifts from strong ties and borrowing from local moneylenders when microcredit is present.

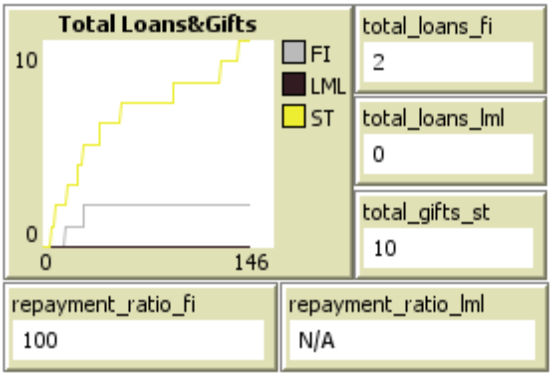


Figure 5: Plot and monitors showing the total number of loans from financial institutions and local moneylenders, the total number of gifts received by strong ties (relatives and friends), and the repayment ratio of the loans.

As we can see from Figure 4, the number of microcredit loans is very low (just two), while the number of gifts from strong ties is higher (ten). The first result depends on the fact that there are still many poor individuals who are not informed about microcredit, and the second one is consistent with our starting assumption of having a network characterized by the presence of many strong ties. Moreover, after 121 ticks, nobody has received loans from local moneylenders. This implies that, as Figure 5 shows, just two microenterprises are created (compared to twenty ordinary enterprises).

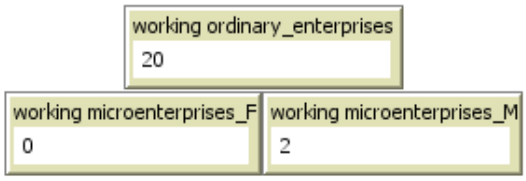


Figure 6: Monitors indicating the number of working ordinary enterprises and microenterprises.

Therefore, structural holes emerge; Figure 6 provides us with a snapshot of this problem. As previously said, the tool through which we represent the idea of a productive chain, is the recipe. Not ended recipes mean that some enterprises, capable to produce certain steps of a recipe, are missing.

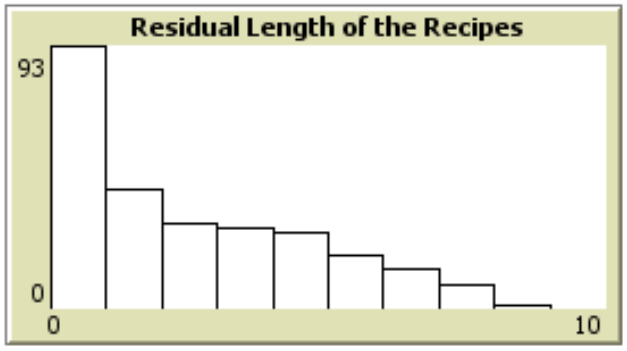


Figure 7: Histogram depicting the global variable “list_of_recipe_lengths”, i.e. the residual length of the recipes of all orders.

Obviously, the presence of structural holes in the network of enterprises implies that a lower number of final products can be produced. Figure 7 summarizes the starting assumptions related to production and trade. The outcome is shown in Figure 8.

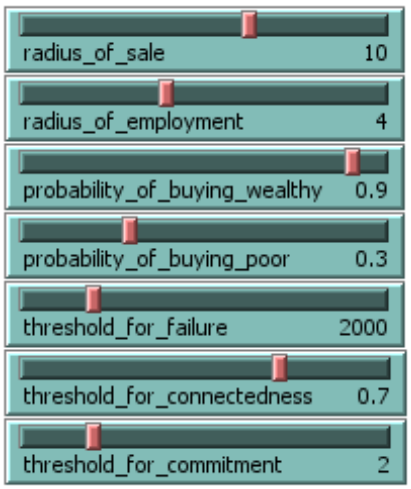


Figure 8: Sliders concerning Production and Trade.

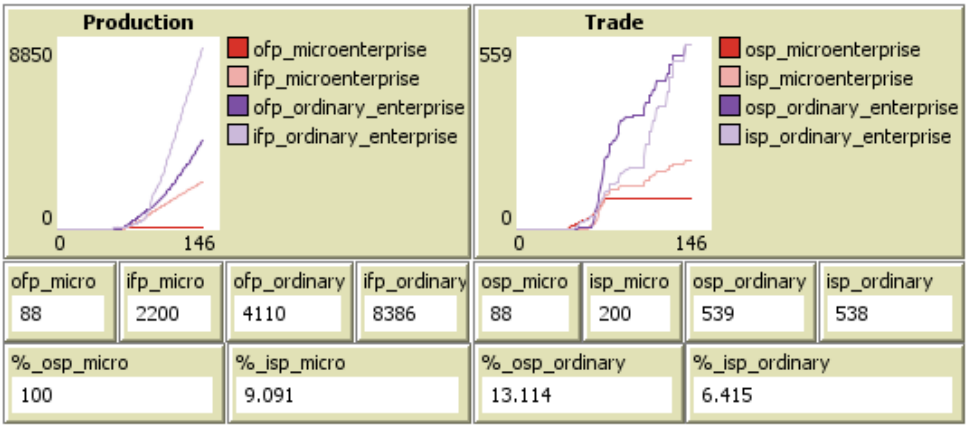


Figure 9: Plots depicting the production and trade processes. The first plot depicts the number of ordinary and innovative final products made by microenterprises and ordinary enterprises, respectively. The second plot depicts the number of ordinary and innovative final products sold by microenterprises and ordinary enterprises, respectively. Below them, the first row of monitors report the total number of created and sold products, while the second row shows the percentages of ordinary and innovative products sold by microenterprises and ordinary enterprises.

From Figure 8, we note that the number of ordinary products made by ordinary enterprises is far higher than the number of ordinary products made by microenterprises (4110 against 88), and the same holds for innovative products (8386 against 2200). This is consistent with the fact that there are just two microenterprises compared to twenty ordinary enterprises. We recall that innovative products are generated when two essential requirements are satisfied: the eigenvector centrality of each enterprise

involved in the productive chain is larger than a certain threshold, and the relationship commitment among the participants of the productive chain is larger than a certain threshold. By considering a value of 0.7 and 2 for the two thresholds (as Figure 7 shows), we get that the number of innovative products is higher for ordinary enterprises. A first explanation of this result could be that ordinary enterprises are more connected than microenterprises. This is confirmed by both Figure 10 and Figure 11, showing the degree distribution and the eigenvector centrality of enterprises.

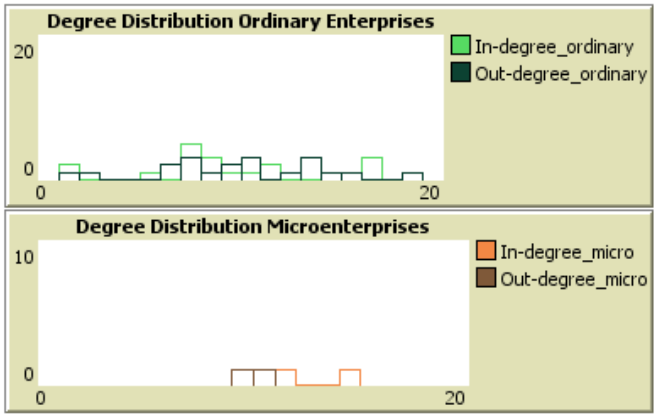


Figure 10: Plots depicting the degree distribution of ordinary enterprises and microenterprises, respectively.

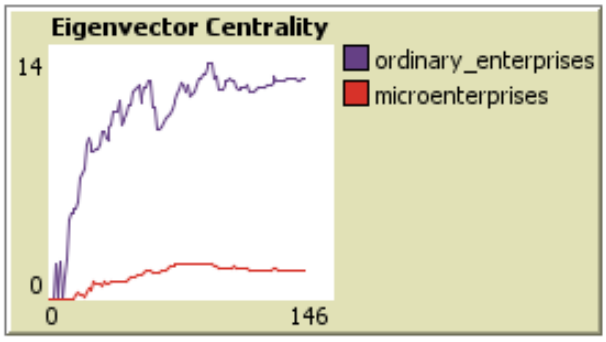


Figure 11: Plot illustrating the eigenvector centrality of ordinary enterprises and microenterprises.

Figure 12 illustrates the "Consumer Satisfaction" plot, which is based on a key assumption about consumer's preferences, usually made by economists: the non-satiation property. It states that greater quantities of goods provide greater levels of satisfaction to the individual. Thus, we consider the number of bought products as a

proxy for consumer's satisfaction. However, assuming that consumers prefer innovative products to ordinary ones, a comparison is needed: if the total number of innovative products is higher than the total number of ordinary products bought by consumers, their level of satisfaction is going to be higher.

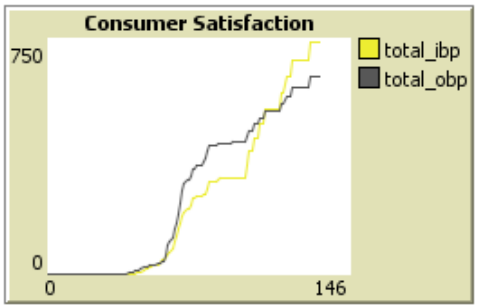


Figure 12: Plot depicting the total number of innovative products bought by consumers (yellow line), compared to the total number of ordinary products bought by consumers (dark grey line).

As we can see from the Figure above, the total number of ordinary products bought is higher than the total number of innovative products bought, thus the level of satisfaction of consumers is not so high. However, as time goes by, the total number of innovative products bought start rising slightly.

Figure 13 shows how the average income of ordinary enterprises and poor people evolves over time. Note that the red line depicts the average income of all poor, including those who start a microenterprise (and thus earn some money from production) and those who do not start a business, consume and can be hired by the enterprises. Due to the scarce number of microenterprises (which is a consequence of the lack of perfect information), the average income of poor people is slightly increasing but it is far lower than the one of ordinary enterprises.

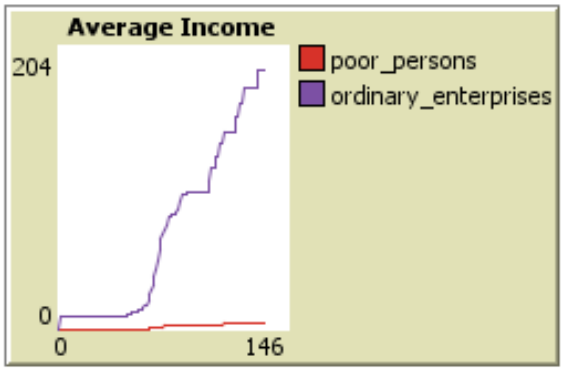


Figure 13: Plot representing the evolution of the average income of ordinary enterprises and poor people.

Figure 14 shows our starting assumption related to the percentage of money invested in the household by poor men and poor women. In accordance with the literature, we make the plausible hypothesis that women and men invest 80% and 40% of what they earn, respectively.

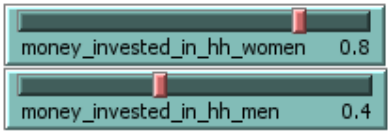


Figure 14: Sliders concerning the percentage of earnings invested in the household by women and men respectively.

Figure 15 shows the outcome of this assumption, combined with the other starting conditions previously defined. In fact, we can immediately note that women are not investing anything because they are not producing. We recall that all poor have two main obstacles to accessing microcredit loans: information, and the judgement of financial institutions, based on the analysis of the individual's entrepreneurial attitudes and abilities. In this experiment, the majority of poor is uninformed about microcredit and thus, they are excluded from formal lending. In addition to that, assuming that the threshold for accessing a microcredit loan is equal to 4, it might be the case that those women which are informed have a low entrepreneurial attitude and thus they are not accepted by financial institutions, or maybe they live far away from them. Thus, in order to help women starting production, information should be spread more widely and financial institutions should facilitate their access to microcredit loans.

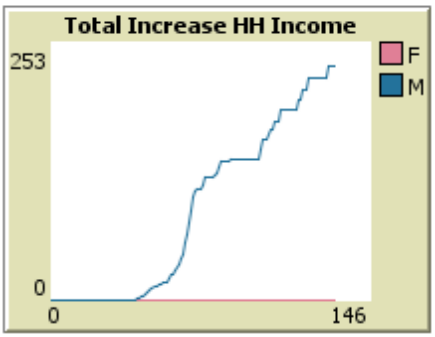


Figure 15: Plot showing the total increase in household income of the poor due to the investment of earnings.

Finally, assuming a value equal to 3 for the slider "ethics_and_CSR_of_microenterprises", shown in Figure 15, we can derive the graph of the social weighted impact of microenterprises, illustrated by Figure 17.

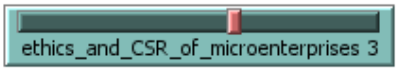


Figure 16: Slider concerning the level of ethics and corporate social responsibility owned by all microenterprises.

By the same argument just presented, in Figure 17 we only find the social weighted impact of microenterprises led by men, since no women is leading a microenterprise.

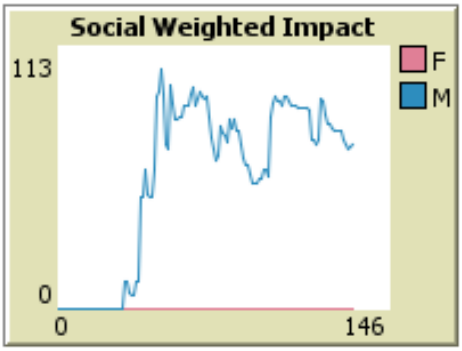


Figure 17: Plot illustrating the social weighted impact of microenterprise.

3.6.1.2 Predominance of Strong Ties and Large Propaganda Effect

From the model of microcredit for rural household presented in Chapter 1, we learn that the role of propaganda concerning microcredit is significant, especially in rural areas. Thus, we are going to test whether, by changing our starting assumption on the propaganda effect and leaving all other conditions unchanged, the outcomes of our model are different. As shown in Figure 18, we now assume that the propaganda effect is 0.9.

Figure 18: Slider concerning the magnitude of the propaganda effect, i.e. the probability for uninformed individuals of becoming informed through their exposure to propaganda.

By increasing the probability of being affected by propaganda exposure, 152 more individuals with respect to the previous situation become informed, as Figure 19 shows.

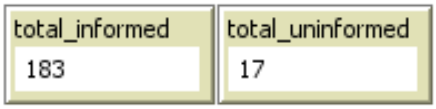


Figure 19: Monitors counting the number of informed and uninformed poor people.

Thus, as illustrated in Figure 20, after being informed, a larger number of poor will ask for a microcredit loan. The total number of microcredit loans is now 26, and the number of gifts from strong ties slightly decreases.

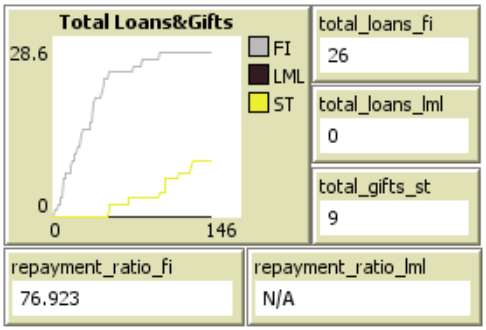


Figure 20: Plot and monitors showing the total number of loans from financial institutions and local moneylenders, the total number of gifts received by strong ties (relatives and friends), and the repayment ratio of the loans.

Thus, as Figure 21 highlights, 26 microenterprises are created and, after 121 ticks, 23 microenterprises are still working (three have failed).

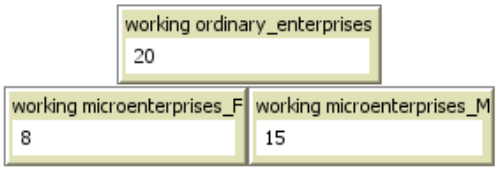


Figure 21: Monitors indicating the number of working ordinary enterprises and microenterprises.

Figure 22 provides a glimpse of how microenterprises can fill structural holes in the network of enterprises. In fact, now, almost all recipes can be completed.

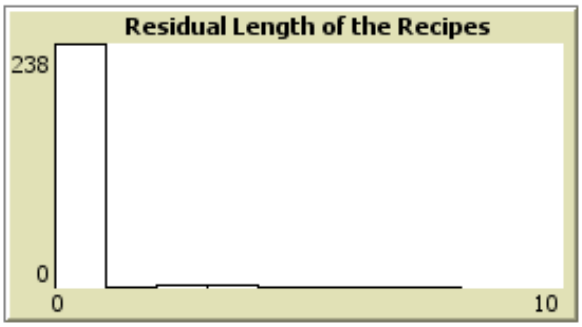


Figure 22: Histogram depicting the global variable “list_of_recipe_lengths”

This implies that more final products can be produced and traded, as graphically shown by Figure 23.

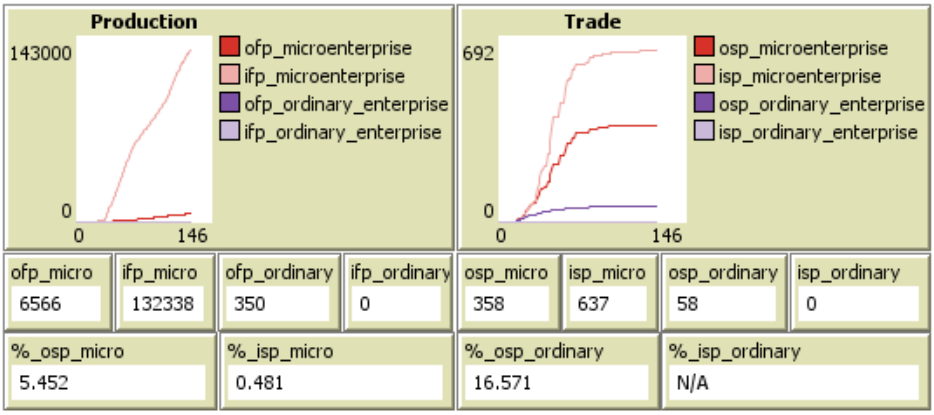


Figure 23: Plots depicting the production and trade processes.

In particular, we note that both ordinary and innovative products made by microenterprises are far higher than the ones made by ordinary enterprises. The reason is that microenterprises are cheaper than ordinary enterprises and thus, if there is a microenterprise capable to execute the same step as an ordinary enterprise, the former is chosen. In addition, the number of innovative products created by microenterprises is very high, this means that, in each productive chain, they are very connected (as confirmed by both Figure 24 and Figure 25), and the the relationship commitment level is high.

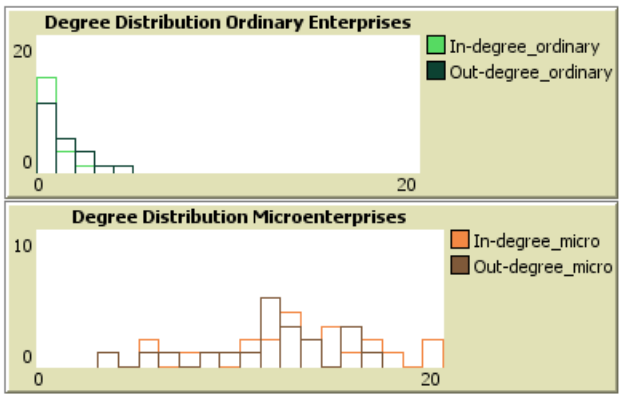


Figure 24: Plots depicting the degree distribution of ordinary enterprises and microenterprises, respectively.

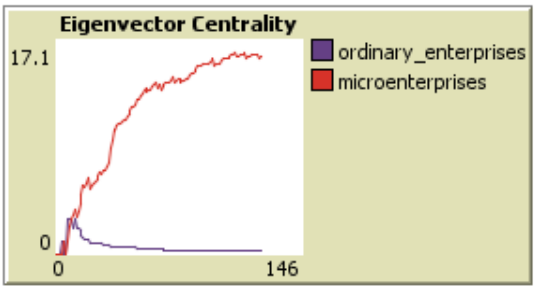


Figure 25: Plot illustrating the eigenvector centrality of ordinary enterprises and microenterprises.

There idea behind this measure is that there are some positive externalities arising from specialization and coordination among enterprises. Thus, with microcredit, which allows the creation of a bigger network of enterprises, positive externalities are stronger. In fact, microenterprises can benefit from having linkages with other microenterprises and also with larger enterprises, since they may strengthen their productive capacities and foster innovativeness.

As we can see from Figure 26, consumer satisfaction is higher than the previous case, since the total number of innovative products bought is higher than the total number of ordinary products bought.

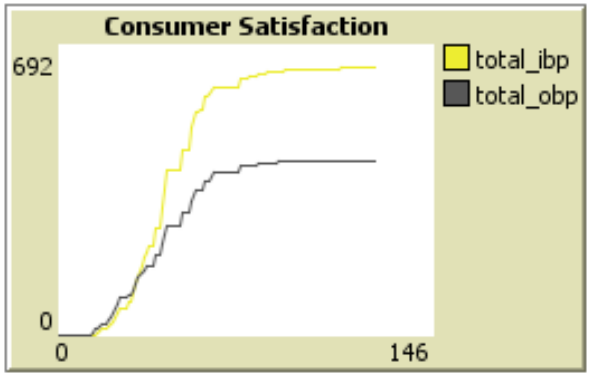


Figure 26: Plot representing consumer satisfaction.

From Figure 27, we can notice that the average income of the poor increases until closing the income gap with ordinary enterprises. In fact, the poor who started a microenterprise can earn from production and those who did not start a business can be employed by microenterprises or by ordinary enterprises.

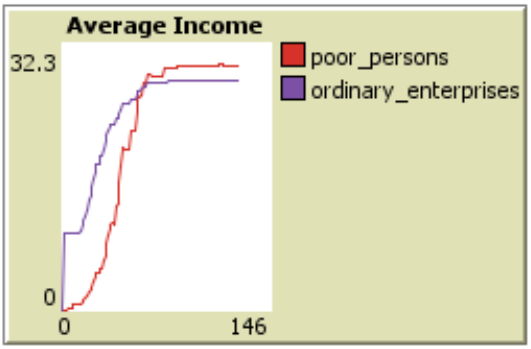


Figure 27: Plot showing the average income of poor people and ordinary enterprises.

From Figure 28, we can see that the increase in household income is higher than before, and that female participation is now present (there are 8 microenterprises led by women and 15 microenterprises led by men).

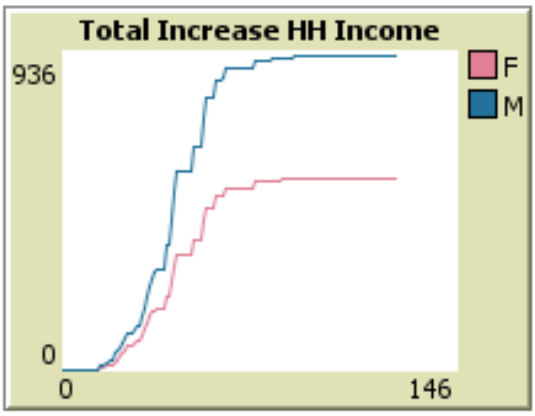


Figure 28: Plot representing the increase in household income due to investment of earnings from production.

Figure 29 illustrates how the social weighted impact is far higher than before. We recall that this measure is computed by multiplying the level of ethics and corporate social responsibility of each microenterprise by its betweenness centrality. The idea is that, as more microenterprises start operating, structural holes are filled and, as we have seen in Chapter 2, entrepreneurs who play the role of brokers across structural holes in the network have a high betweenness. Moreover, they are able to access information from diverse sources and clusters, and this interpretation is consistent with the fact that

microenterprises produce a large number of innovative products. Figure 30 shows how, by introducing more microenterprises, the betweenness of a larger number of nodes increase. Thus, positive externalities are transmitted to a bigger network.

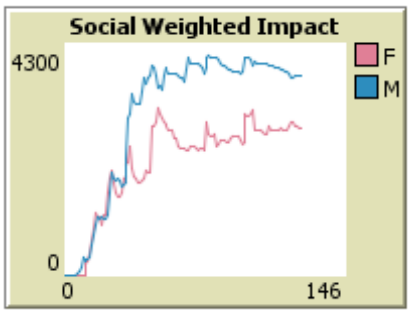


Figure 29: Plot illustrating the social weighted impact of microenterprises.

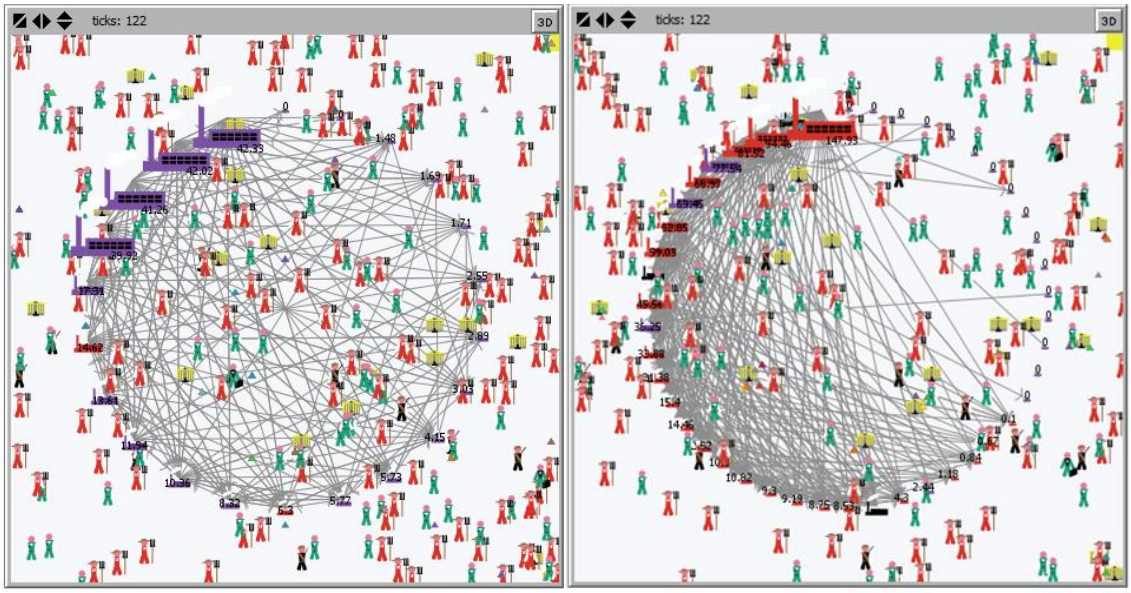


Figure 30: Betweenness centrality values of enterprises in the case of negligible propaganda effect (view on the left-hand side) and large propaganda effect (view on the right-hand side).

Given these assumptions, if we compare such situation with one in which the minimum level of "entrepreneurial_attitude" necessary for accessing microcredit loans is set at 3 (see Figure 31), a larger number of poor would have the possibility to start a microenterprise. In particular, as Figure 32 reports, with respect to the situation in which the threshold was set at 4, leading to 8 microenterprises led by women and 15

microenterprises led by men, we now have 24 microenterprises led by women and 17 microenterprises led by men.

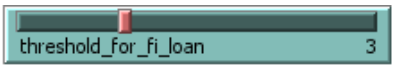


Figure 341: Slider concerning the limit of entrepreneurial attitude necessary for accessing microcredit loans by financial institutions.

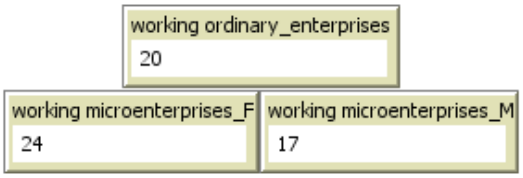


Figure 32: Monitors counting the number of working ordinary enterprises and microenterprises.

Thus, facilitating the access to microcredit will empower women. We expect that, by increasing the number of microenterprises led by women, the total increase in household income and the social weighted impact of microenterprises will be higher. This is confirmed by both Figure 33 and Figure 34

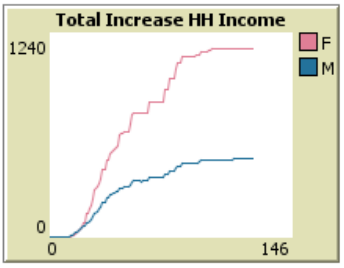


Figure 33: Plot describing the increase in household income.

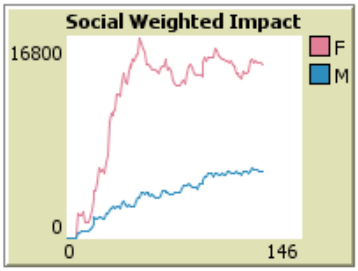


Figure 34: Plot describing the social weighted impact of microenterprise.

3.6.1.3 Predominance of Weak Ties and Negligible Propaganda Effect

The third experiment we want to perform, is exactly the same as the first one in terms of starting assumptions, the only difference is that we now consider a network of individuals characterized by the prevalence of weak ties over strong ties, as shown by the monitors in Figure 36. This is achieved by increasing the value of the slider in Figure 35 up to 0.9.

Figure 35: Slider influencing the probability of having a network with a certain type of ties.

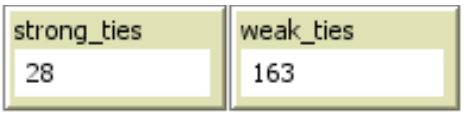


Figure 36: Monitors reporting the total number of strong ties and weak ties.

As always, the number of informed individuals at the beginning is two; after leaving the program run for 121 ticks, thanks to the world-of-mouth process, 41 individuals become informed (i.e. 14 more individuals with respect to the first experiment). Thus, the world-od-mouth process is more effective when there are more weak ties than strong ties. This is illustrated in Figure 37.

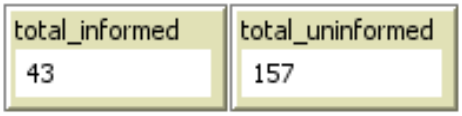


Figure 37: Monitors counting the total number of informed and uninformed individuals.

Figure 38 shows that more microcredit loans are now provided by financial institutions (given that the demand for loans by informed poor has increased), and the number of

gifts received by strong ties is lower (which consistent with our starting assumption of having a network with more weak ties than strong ties).

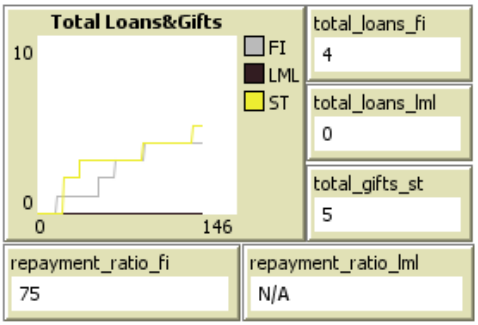


Figure 38: Plot and monitors showing the total number of loans from financial institutions and local moneylenders, the total number of gifts received by strong ties (relatives and friends), and the repayments ratio of the loans.

Thus, 2 more microenterprises are created with respect to the first experiment. After 121 ticks there are 3 microenterprises (one has failed) and 19 ordinary enterprises (one has failed).

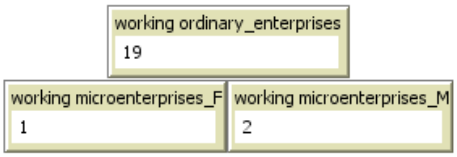


Figure 39: Monitors counting the number of working ordinary enterprises and microenterprises.

As Figure 40 shows, compared to Figure 7, there is a lower number of recipes which are not ended, and thus, less structural holes in the network.

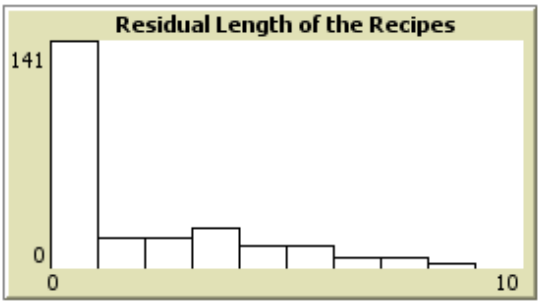


Figure 350: Histogram depicting the residual length of the recipes of all orders.

Thus, more final products are produced, as highlighted by Figure 41.

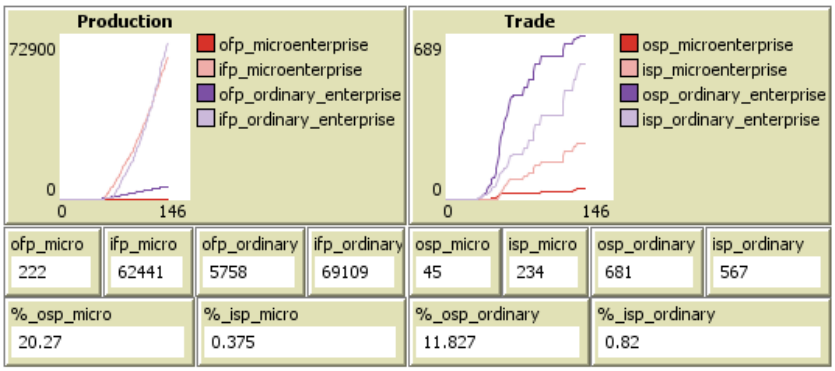


Figure 41: Plots describing the production and trade processes.

Comparing Figure 42 and 43 with Figure 10 and 11, we can see that microenterprises are now slightly more connected and their eigenvector centrality is increasing.

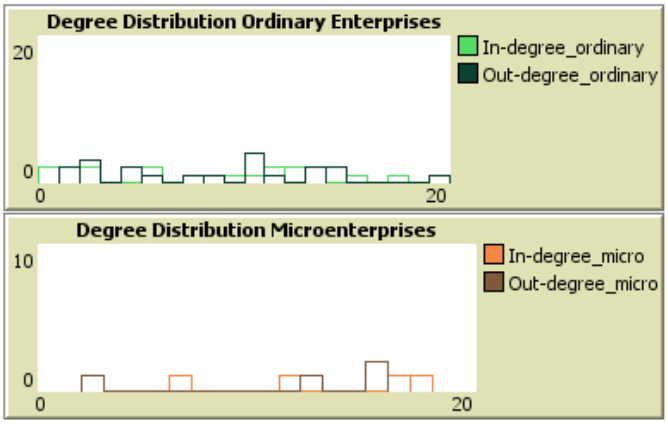


Figure 42: Plots depicting the degree distribution of ordinary enterprises and microenterprises, respectively.

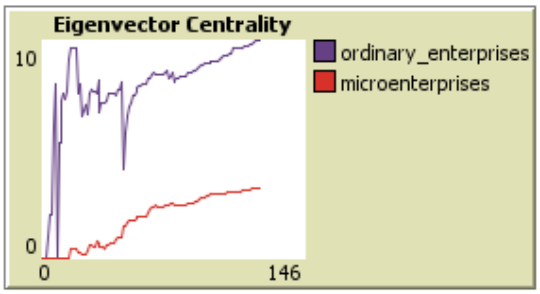


Figure 43: Plot illustrating the Eigenvector centrality of ordinary enterprises and microenterprises.

Comparing Figure 44 to Figure 12, we notice that consumer satisfaction is now slightly higher.

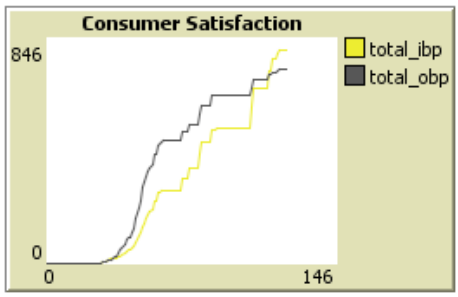


Figure 44: Plot representing consumer satisfaction.

Compared to Figure 11, Figure 45 shows that the average income of poor people and ordinary enterprises is slightly higher.

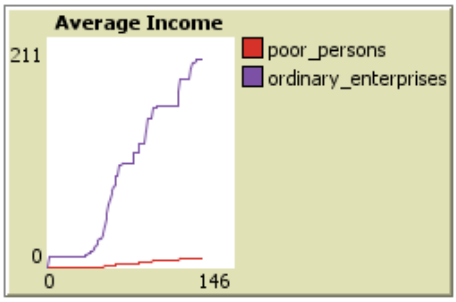


Figure 436: Plot illustrating the average income of poor people and ordinary enterprises.

Comparing to Figure 15 and 17, Figure 46 shows that female participation is now present.

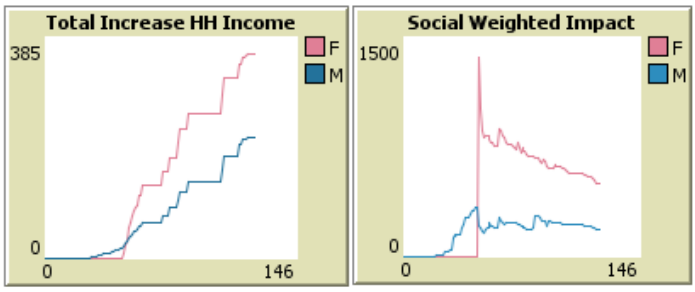


Figure 437: Plot showing the total increase in household income (left-hand side) and the social weighted impact of microenterprises (on the right-hand side).

If we consider a large propaganda effect in this context, characterised by more weak ties than strong ties, we obtain very similar results to the ones obtained in the second experiment, based on a network with more strong ties than weak ties. Hence, we do not report the results and we claim that increasing the propaganda effect is beneficial, independently of the features of the ties in the network.

3.6.2 Experiments without microcredit

If microcredit is absent, i.e. the switcher "microcredit" is off (as shown in Figure 47), the aforementioned discussion on information does not apply. Thus, we only focus on two experiments: the first will be conducted in a context characterised by the predominance of strong ties and the second one by the predominance of weak ties.

Figure 438: Switcher allowing the possibility to eliminate microcredit from our simulation

3.6.2.1 Predominance of Strong Ties

We start from the same initial conditions as experiment 1. In Figure 48, we report some sliders which were not used before, since they refer to the probabilities of borrowing from local moneylenders and receiving gifts when microcredit is absent. Our objective is to analyse what happens in the absence of microcredit, considering a network of individuals characterized by the prevalence of strong ties over weak ties.

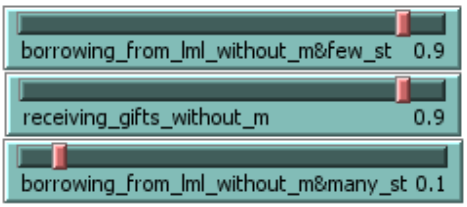


Figure 439: Sliders concerning the probabilities of borrowing from local moneylenders and receiving gifts when microcredit is absent.

As we can see from Figure 48, the amount of gifts received by strong ties is high, as well as the amount of loans received by local moneylenders.

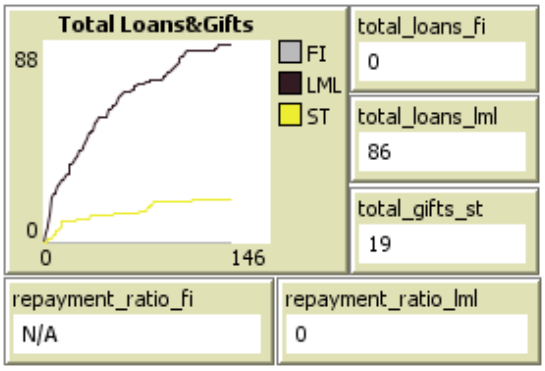


Figure 440: Plot and monitors showing the total number of loans from financial institutions and local moneylenders, the total number of gifts received by strong ties (relatives and friends), and the repayments ratio of the loans.

As Figure 49 illustrates, the total number of microenterprises which are created thanks to informal credit is quite low (just five).

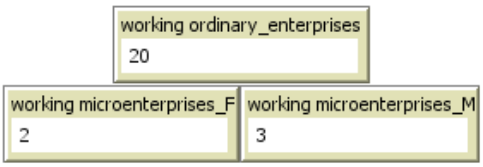


Figure 50: Monitors indicating the number of working ordinary enterprises and microenterprises.

Thus, there are structural holes which cannot be filled by microcredit as before and, as Figure 51 illustrates, a lower number of final products are created.

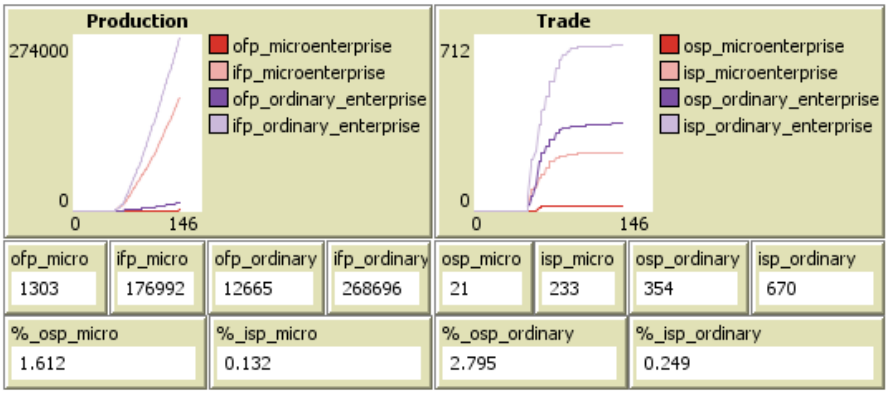


Figure 51: Plots depicting the production and trade processes.

As Figure 52 and 53 highlight, microenterprises are less connected than ordinary enterprises.

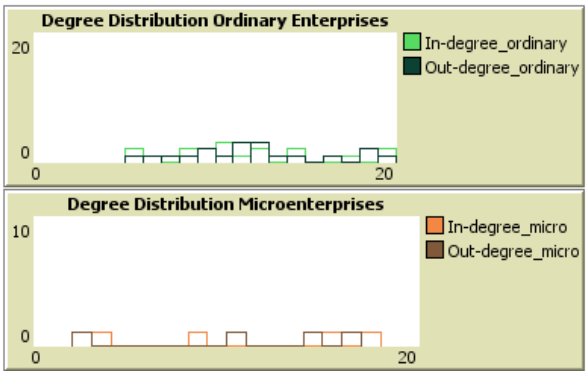


Figure 52: Plots depicting the degree distribution of ordinary enterprises and microenterprises, respectively.

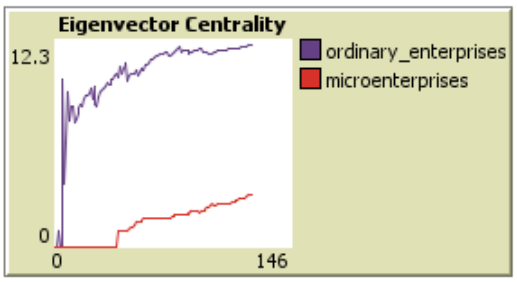


Figure 53: Plot illustrating the Eigenvector centrality of ordinary enterprises and microenterprises.

Consumer satisfaction, represented in Figure 54, is higher than before because the number of innovative products bought is higher than the number of ordinary products bought.

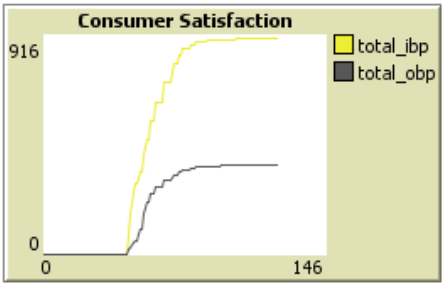


Figure 54: Plot illustrating consumer satisfaction.

Figure 55 gives a glimpse of the fact that, without microcredit and relying on informal credit only, the average income of the poor remains extremely low.

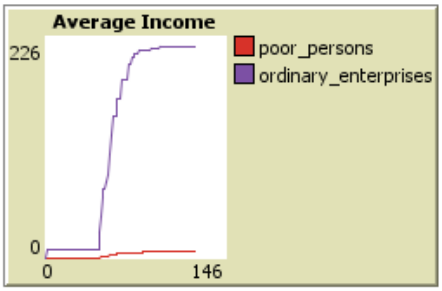


Figure 55: Plot depicting the average income of poor people and ordinary enterprises.

Given that two out of five microenterprises are led by women, as shown in Figure 56, female participation in the production process has a significant impact on society.

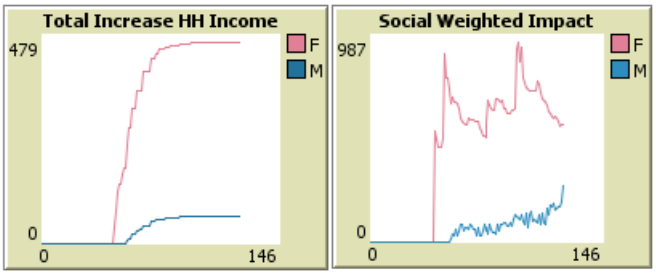


Figure 56: Plot showing the total increase in household income (left-hand side) and the social weighted impact of microenterprises (on the right-hand side).

3.6.2.2 Predominance of Weak Ties

We now focus on the case of predominance of weak ties over strong ties. From Figure 57, we immediately note that the number of gifts received from strong ties is extremely low and the number of loans received from local moneylenders is higher than the previous case.

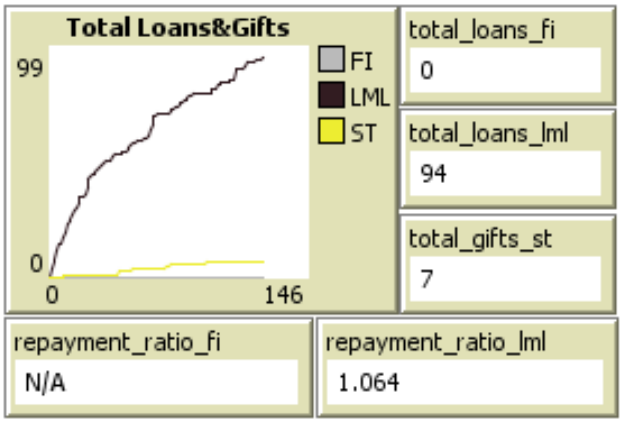


Figure 57: Plot and monitors showing the total number of loans from financial institutions and local moneylenders, the total number of gifts received by strong ties (relatives and friends), and the repayments ratio of the loans.

As Figure 58 highlights, only two microenterprises are created.

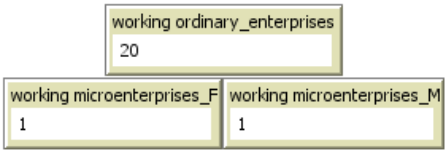


Figure 58: Monitors indicating the number of working ordinary enterprises and microenterprises.

Thus, structural holes emerge, as Figure 59 confirms, and a lower number of final products are realized, as illustrated in Figure 60.

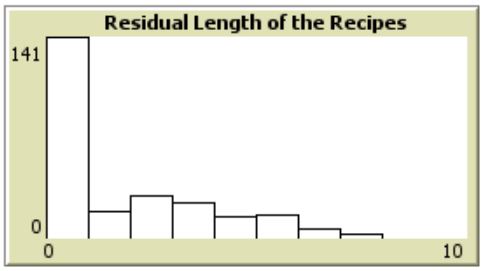


Figure 59: Histogram depicting the residual length of the recipes of all orders.

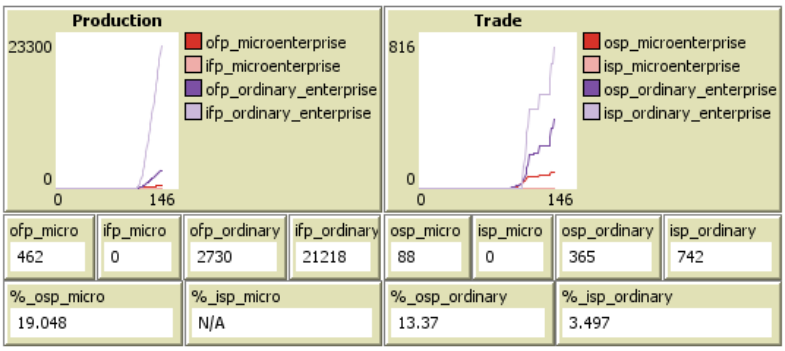


Figure 60: Plots depicting the production and trade processes.

The interesting thing to notice in Figure 60, is that, thanks to microcredit, not only microenterprises can operate, but also ordinary enterprises can become operative: without microcredit (or, if present, without an adequate level of information about it), some ordinary enterprises, specialized in executing a certain step of a recipe, may be inactive because there are no enterprises capable to execute the next step of a recipe.

Figure 61 highlights the level of connectedness of microenterprises, far lower than the one of ordinary enterprises.

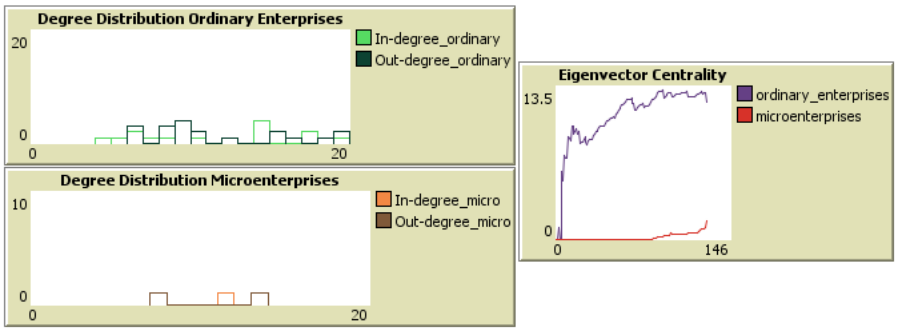


Figure 61: Plot showing the Degree distribution (left-hand side) and the Eigenvector Centrality (right-hand side) of microenterprises and ordinary enterprises.

Moreover, even if the total number of innovative products bought from consumers is higher than the total number of ordinary products bought from consumers, the level of consumer satisfaction is clearly lower than the previous case.

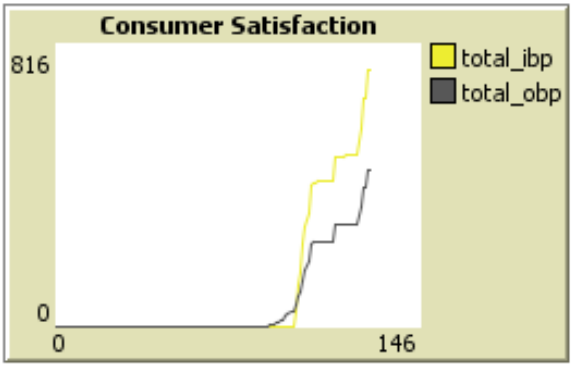


Figure 62: Plot representing consumer satisfaction.

Figure 63 confirms our interpretation: the average income of the poor is extremely low and the one of ordinary enterprises can start rising only when at least one microenterprise starts operating.

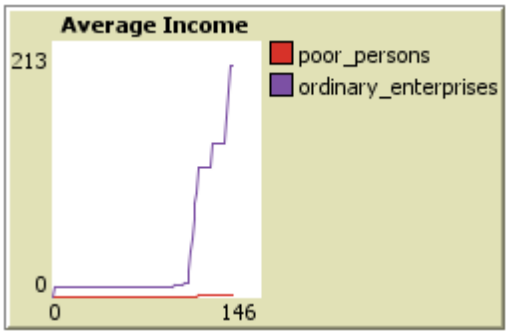


Figure 63: Plot illustrating the average income of poor individuals and ordinary enterprises.

Note that, if we consider a thicker network of individuals (and this can be achieved by reducing the value of the slider "connection_strength_threshold", in Figure 64), the differences between these two experiments are stronger.

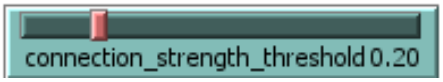


Figure 64: Slider determining the dimension of the network of persons

We can analyse Figure 65 and 66, comparing them to Figure 49 and 50. If the poor can rely on a bigger network of strong ties, the number of gifts received from them will be higher and the number of loans received by local moneylenders will be lower. The support from strong ties is important also to pay back the loans to local moneylenders. Comparing Figure 66 to Figure 50, we can notice that, in this case, more microenterprises can be created thanks to informal lending (but they are still less than the case in which microcredit is present and information is widespread).

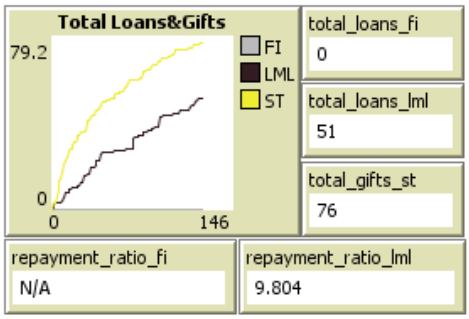


Figure 65: Plot and monitors showing the total number of loans from financial institutions and local moneylenders, the total number of gifts received by strong ties (relatives and friends), and the repayments ratio of the loans.

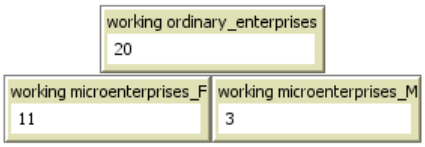


Figure 66: Monitors indicating the number of working ordinary enterprises and microenterprises.

By considering the same thicker network, but characterized by the predominance of weak ties over strong ties, we notice that the difference with respect to the previous case is more evident. As highlighted by Figure 67 and 68, given that people can rely less on strong ties, the amount of loans from local moneylenders is much higher, and the repayment ratio is low. The number of microenterprises that can be created thanks to informal credit is now lower.

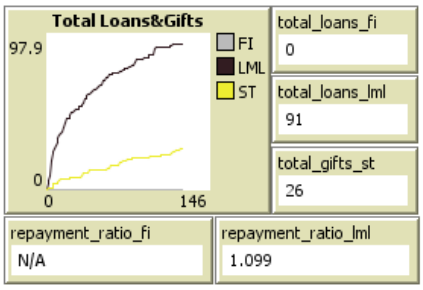


Figure 67: Plot and monitors showing the total number of loans from financial institutions and local moneylenders, the total number of gifts received by strong ties (relatives and friends), and the repayments ratio of the loans.

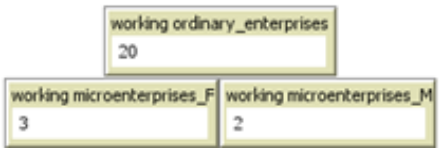


Figure 68: Monitors indicating the number of working ordinary enterprises and microenterprises.

Conclusions

Our work tries to address the role of microcredit in an abstract developing country. As a theoretical benchmark, we consider the case of China, since it represents an ideal candidate for implementing microcredit services. In Chapter 1, after an overview on the history of microcredit in China, we have reviewed the literature discussing the role of microcredit in rural areas, the social role of microenterprises (paying particular attention to the ones led by women), and the role of Guanxi networks in China. In Chapter 2, we have discussed the method chosen to analyse these insights, which is a combination of agent based simulation modelling and network analysis. Finally, in Chapter 3, we have described in detail the features of our model and the experiments we have conducted. In what follows, we are going to present the main contributions of our model and some suggestions about further research.

RESULTS

In order to analyse the role of microcredit in a developing context, in Chapter 3 we conduct two sets of experiments, one when microcredit is present and the other one when microcredit is absent. As far as the first set of experiments is concerned, we focus on the role of information spreading, since it represents the first fundamental prerequisite for accessing formal credit. We find that:

(i) In a person-to-person network characterized by a prevalent number of strong ties (relatives and friends), the world-of-mouth process is not very effective.

(ii) In a person-to-person network characterized by a prevalent number of weak ties (acquaintances), the world-of-mouth process is more effective.

(iii) Independently of the predominant type of ties in a person-to-person network, the w-o-m process is more effective if the effect of propaganda increases.

The finding that weak ties are more effective in facilitating information diffusion is in line with the literature (Granovetter, 1973). The reason is that more novel information flows to individuals through weak rather than strong ties. In fact, on one side, close friends and relatives tend to move in the same directions that we do, thus the information they receive overlaps considerably with what we already know. On the other side, acquaintances, know people that we do not, and thus receive more novel information.

The discussion about the transmission of information through the social network is of utter importance, since the lack of information represents the first main obstacle to accessing microcredit. In fact, if the majority of poor people are uninformed about microcredit loans, the results will be similar to the case in which microcredit is absent. In particular we find that:

(i) The business-to-business network is less dense and more fragile: there are structural holes, i.e. missing enterprises capable to produce a certain step of a recipe, and fewer enterprises with high betweenness centrality.

(ii) The presence of structural holes implies that a lower number of final products can be created, both because the number of enterprises is lower than the case in which structural holes are filled and because some of the existing enterprises cannot operate since there is no enterprise capable to execute the following step of a recipe.

(iii) If the business-to-business network is less dense, it will be more difficult to produce innovative products. In fact, innovative products can be obtained when the levels of B-B Guanxi (to use a Chinese concept, explained in Chapter 1) and relationship commitment are sufficiently high. As a measure of B-B Guanxi we have considered the Eigenvector Centrality of the enterprises participating in each production chain, while the relationship commitment level is assigned randomly but it is likely to increase if more links among enterprises are generated.

(iv) Provided that consumers prefer products that offer more innovative features, buying less innovative products implies having less satisfaction.

(v) The average income of the poor remains low.

(vi) If information is not widespread, it is likely to have an underrepresentation of women in production. This is a loss for society, since microenterprises led by women have a higher level of ethics and corporate and social responsibility and they invest a higher amount of earnings in their households with respect to men.

In contrast, if microcredit is present and information is widespread, we find that:

(i) The business-to-business network is denser and less fragile, since microenterprises fill structural holes and there are more enterprises with high betweenness centrality.

(ii) More final products can be created.

(iii) As the size of the business-to-business network increases, it is more likely for enterprises to produce innovative products. In fact, both the Eigenvector Centrality and the relationship commitment levels of enterprises involved in the same production chain are likely to increase.

(iv) Consumers have the possibility to buy more innovative products and thus are more satisfied.

(v) The average income of the poor increases. Thus, microcredit can be a way to reduce income inequality in developing countries and a step towards the fight of absolute poverty and the emancipation of the poor.

(vi) Women have more chances to start a microenterprise and, if this happens, they give a positive contribution to their households and to the society as a whole.

By performing also experiments in the absence of microcredit, we conclude that interpersonal networking is crucial for two reasons:

(i) It serves as a fundamental channel for information, when microcredit is present.

(ii) It can be an economic resource when formal credit is absent. In particular, a network characterized by the prevalence of strong ties allows the poor to rely less on local moneylenders and eventually to start microenterprises.

FURTHER RESEARCH

Obviously, further research and scientific insights can still be explored. An interesting development of this model could include the considerations made by Vineis et al. (2015). According to them, SES (Socioeconomic Status) across the life course is a major determinant of adult health and disease. Low SES across the life course is related to early death and poor ageing. As shown in Figure 1, ageing can be viewed as a two-stage process: a "build-up" phase, which starts at conception and ends with late adolescence, and a "decline" phase, which starts from early adulthood and ends with death. Environmental exposures in the "build-up" phase have an impact on future ageing trajectories (as the dotted line in Figure 1 shows).

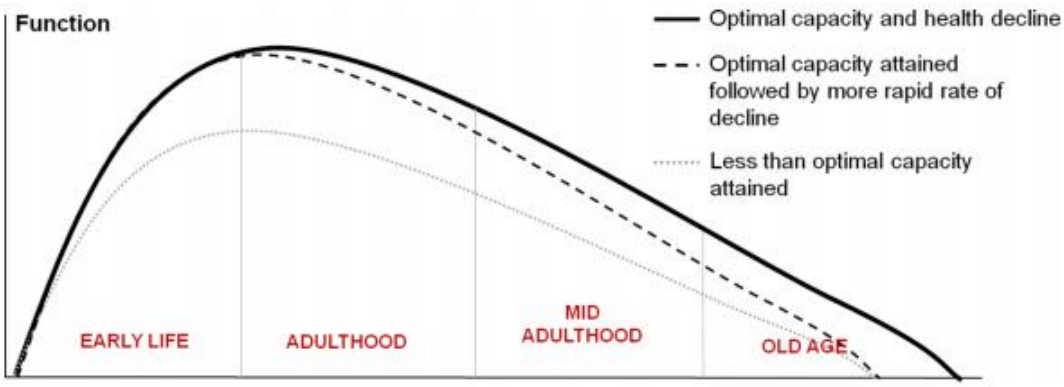


Figure 41: Life course health trajectories, Vineis et al., 2015.

The reason is that, during the first stage, socioeconomic conditions may induce some epigenetic modifications, which may be inherited by children.

Thus, by inducing a change in SES, microcredit may have consequences not only on the living standards of the poor but also on her DNA. This consideration provides an interesting stimulus to research in the field.

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