SOCIAL INNOVATION CHAINS
A Nanovaccine as a Case of Social Inclusion

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Abstract: The benefits of nanotechnology could be traced across different industries and, with a responsible governance, could help with social problems. This paper engages with the contingent nature of social innovations, proposing a narrative chain that explain why the production of a new brucellosis nanovaccine in Patagonia, could have positive impact in social inclusion in the Argentine context. In particular, the mentioned nanovaccine will help reducing ovine brucellosis, increasing local production and local labor. This work argues that promoting this micro policy, would increase social inclusion in Patagonia.

Keywords: Social Innovation, Social Inclusion, Nanovaccine, Brucellosis, Rural Poverty

1. Introduction

> Nanotechnologies are the design, Characterisation, production and application of structures, devices and systems by controlling shape and size at nanometer scale.
> (The Royal Society & The Royal Academy of Engineering, 2004 p.5)

> Social innovations are regarded as new products, processes and methods that, in a creative and sustainable manner, offer a better solution to one or several social demands.
> (Unceta, Castro-Spila & García-Fronti, 2016 p.2).

Benefits of nanotechnology could be traced across different industries, promising new solutions to social problems. These aggregated promises, which are in permanent interaction with public policies, sustain future expectations, pressuring the process of allocation of national public resources, and defining the future of society in its whole (Van Lente, 1993; Van Lente & Rip, 1998). One of the most important and promising area is the use of nanocarriers to increase the efficient of vaccines and drug treatments.

The idea of social innovation is a concept taking a number of different meanings (many of them discipline-specific). Four general conceptions of the term are noted by (Pol and Ville, 2009), which we now reproduce in summary. The first conception emphasizes social innovation as a driver of institutional change (taken to be any cultural, normative, and regulative change from the previous structure). The second one is that of the Young foundation which is that a social innovation is an innovation that seeks to resolve a social need (Mulgan, Tucker, Ali, and Sanders, 2006). The third one, forwarded by the Centre for social innovation, takes a social innovation to be anything that works for the public good (i.e. resolving social needs), although this definition does not seem to add anything to the debate, the same paper adds that a *true* social innovation is one that permanently alters the behaviours and structure of the relevant agents in question. The last conception is that of social innovation as addressing needs ignored by the market.

In line with (Unceta, Castro-Spila, and Garcia Fronti, 2016) we take for the working definition of social innovation to be a way of resolving market or State failures, (i.e to resolve social needs) that also changes the behaviour of the agents involved in a meaningful manner. The authors argue that this definition takes several of the most important ideas from the previously presented general conceptions.

Social innovation many times emerges as a *chain* that starts with a technological innovation and, after various links, impacts positively in social inclusion. Appealing to the contingent nature of innovation, this paper analyzes the chain that allows to understand why promoting the production and use of a new brucellosis nanovaccine is a social innovation that is socially desirable in the Argen-

tine context. The mentioned nanovaccine will help reducing ovine brucellosis in Patagonia, which increases local production. In the particular context of this regional economy, this will increase local labor and will benefit small local producers. This chain of events, will activate the regional economy, several studies demonstrate the high efficiency of these micro policies to increase social inclusion.

Regional economies are crucial for a socially inclusive growth in Argentina (Bekerman & Dalmaso, 2014; Casparri, Fusco, & García Fronti, 2014; Miguez, 2014). One of them -linked to the ovine production- has grown considerably reaching a production of 14.859.486 heads on a national level in March of 2013 (Mueller, 2013b). However, one disease - the ovine Brucelosis - is threatening the industry by producing economic loss to both the producers and the State. The application of a nano-vaccine developed and patented by INTA prevents this disease, having a positive local impact on ovine production (INTA, 2013, 2015; Manazza, Spath, & Paolicchi, 2006; OIE, 2012; SENASA, 2014).

This paper argues that a new nanovaccine against brucellosis in Argentina will boost regional ovine economies, responding to social needs in Patagonia. To achieve this goal, the next section analyses the importance, in economic and social terms, of agrobusiness in Argentina. It intends to use descriptive statistics to ground our hypothesis that there are significant unaddressed social needs in rural Argentina. Section two, describes ovine stockbreeding in Patagonia and its associated social vulnerability issues. Then, this paper examines the new nanovaccine for preventing ovine brucellosis and how it could be implemented in Patagonia.

2. Agro-Industry in Argentina

The agriculture, stockbreeding, forestry, and hunting[1] sector in Argentina accounted for roughly 6.5% in terms of gross added value in 2014 according to the National Institute of Statistics and Censuses (INDEC). According to the 2010 national census, about 8.9% of the population lives in a rural setting, defined as those localities with a population lesser than 2,000. Of them, 36.3% live in small towns (defined as grouped rural population) and 63.7% live in open fields (disperse rural population).

Argentinean poverty measures are restricted to urban areas (Guardia & Tornarolli, 2010). Nevertheless, there is a number of independent studies that have been performed over the years. A survey performed by the World Bank in 2002[2] found that there is a significant gap in well-being among rural and urban households (Mathey, 2007; Haimovich & Winkler, 2005). While 23.5% of the urban population was living under the poverty line, the number went up to 40.2% in rural areas (Fiszbein, Giovagnoli, & Adúriz, 2003). It should be noted that at the time of the survey, Argentina was not only at the bottom of the economic cycle, but rather undergoing one of the worst crisis in its recent history (Conconi & Ham, 2010), and that income based measures of poverty are highly sensible to these events. Yet there is no reason to believe that this gap between urban and rural households has declined, as poverty reduction programs are more easily and often performed on urban, rather than rural areas.

Non income based poverty measures also show significant differences between rural and urban areas, using an unsatisfied basic need (UBN) focus under which any household with at least one UBN is classified as poor. The study finds that 32% of the rural population was poor in 2001, while the measure declined to 16% for the urban population (Demombynes, Metzler, & Verner, 2010). Since 2002, the government has heavily taxed agricultural exports which has had strong positive effects on reducing overall poverty (Cicowiez, Díaz-Bonilla, & Díaz-Bonilla, 2010) while subsidizing utilities and public transport in cities (most notably Buenos Aires metropolitan region) which has had a strong effect on urban poverty and seldom in rural. Also as (Demombynes et al., 2010) note, expenditure and provision of public goods has been inferior in rural areas relative to urban ones. This gap is caused mostly by a lower per capita income in rural areas (95% of the difference explained) rather than differences in income distribution (explaining the remaining 5%). Among the causes of this, the same authors point out lower levels of education among rural areas, which are in time associated with lowered productivity levels, hence the lower per capita income (Haimovich & Winkler, 2005).

In the line of (Verner, 2006) the authors propose that the policy focus should be to increase the productivity of labor and promote employment in rural areas. Historically, poverty reduction has been more effectively reduced by micro-level productive development policies such as the nanovaccine developed by INTA, rather than aggregate level macroeconomic policy (Sánchez, Butler, & Rozemberg, 2011). In the next section the social vul-

[1] Fishing not included.

[2] "Impacto Social de la Crisis en Argentina", methodological information on the survey can be found at http://siteresources.worldbank.org/INTARGENTINAIN SPANISH/Resources/Documento_de_informacion_ basica03.pdf.

nerability of the target population and the importance of ovine production will be studied.

3. Ovine Stockbreeding and Social Vulnerability in Patagonia

The stock of ovine cattle in Argentina is estimated to be between 14 and 15 million heads distributed among 80,000 households (Mueller, 2013b). Ovine production was central to the correct functioning of Argentine economy on the eighteenth century (the country entered the world economy aided by the exports of wool and leather for the European textile industry) but at the turn of the century, the emergence of bovine and agricultural exports displaced ovine production from the Pampa region towards more marginal areas, such as the Patagonia. After this, the relevance of ovine production to Argentina's economy followed at steep, yet inconstant, decline. The last important decrease in stocks came in the early 90's (with stocks declining from 20 to 13.6 million heads) when the prices of wool collapsed (Mueller, 2007). In response to this, the government passed in 2001 a law aiming at the reactivation of ovine production[3], which has been instrumental for a moderate sector recovery.

Although the ovine stockbreeding sector has lost its historical importance, it remains relevant to producers in terms of self-consumption, in supplying local consumers, and for the conservation of forage resources (Mueller, 2013b). As for the uses of Ovine production, both meat and wool production are relevant with milk and its by-products performing only a marginal role in the total. Producers tend to use dual purpose breeds and extensive production methods with allow for low use of inputs, but disallow high reproduction nor high growth rates (Mueller, 2007).

Meat production is estimated to be 55,700 tons per year of which only 9.3% (5,200 tons), the Patagonia is free of foot and mouth disease and mad cow disease which gives great growth potential for exports, especially since the European Union assigns an export quota of 23,000 tons per year which the country severely underuses. The remaining production is devoted to internal consumption of which the great majority (64.7% of the total) corresponds to informal self-consumption, and with only 26% finding its way to the internal market. When it is not used for self-consumption meat production usually accounts for 50% of the producer's income (Mueller, 2013b).

Wool production varies according to climatic conditions, yearly output averaged around 58.3 million of tons for the period 2005-11, of which 90% is exported mainly to Europe, China, Turkey, and Mexico. Producers rely intensely on INTA issued quality certificates (Mueller, 2013b), the same organism offers an ovine genetic evaluation service mainly aimed at breeders called PROVINO (Mueller, 2013a).

Ovine stockbreeding geographic distribution is uneven; 66% of the stock is breed in the Patagonia (Tierra del Fuego, Santa Cruz, Neuquén, Rio Negro, and Chubut) where production takes an extensive mono-production form. Two thirds of the producers have less than 1,000 heads while coexisting with bigger companies managing more than 50,000 heads. One company, Estancias Patagonia S.A, is responsible for half the country's ovine meat exports (Mueller, 2013b). The ovine activity is the most relevant within the agricultural sector in this region (Gatti, 2012).

The remaining 34% is distributed across the country. Here, production is subsidiary to agriculture (as is the case of Buenos Aires), or to other types of stockbreeding (bovine in the Mesopotamic provinces, and camelids and goats in the Northern provinces). Production here is typically smaller with most households managing less than 100 heads, and mainly for own consumption. Unlike its Patagonic counterpart, production in this region is much less sensible to climatic changes (Mueller, 2013b).

To match the diverse production methods with the quality of life conditions of the producers it would be useful to provide with a typology of the (disperse) rural population, even if this is provisory. Sociological studies find that the population may be divided into three types. The first type is that of land owners whose production is channeled within the formal market, this type of producer carries out the greater (relative) scale for its production as it is associated to the hiring of labor. This type is the better well off on its own of the three. It is not, nevertheless, a homogeneous group, as it allows for the distinction between those who produce for the external and internal markets. As for the former this sub-type is the richer one as exporting means that they have access to financing, infrastructure (as ports and roads), and that they have reached a scale that is sufficient to compete with more developed economies such as Australia and New Zealand. They are mainly located in the Patagonia to exploit the comparative advantages of this region. The latter sub-type is mostly not dependent solely (and therefore, not specialized solely) on ovine produc-

[3] http://www.leyovinabuenosaires.com.ar/docs/Ley%2025.422%20y%20Decreto.pdf

tion (such is the case of dual-production in Buenos Aires and the Mesopotamia), this responds to the fact that local demand for ovine products is highly seasonal.

The second type includes those who engage in production for self-consumption. This type is generally poorer than the former but its means of living is still associated to the ownership and/or some form of leasing of the land, which evidences the existence of savings in some form. It usually relies on informal unpaid labor associated to familiar ties and own labor to carry out its production (i.e., pre-capitalistic low-scale farming). Unsurprisingly, ovine producers of this type abound in the Northern provinces, which are the poorest in the country.

The last type is that of those who have no access to land, neither by ownership nor leasing and do not even have the means to start the low-scale farming of the former. It subsists by offering its labor to the other two types of producers (mostly to the first type since the second relies heavily on unpaid labor). This type can be found all over the country and often engages in migrant work as agricultural production in general is seasonal.

Ovine brucellosis (an infectious or contagious epididymitis ram) is an infectious disease, clinical or subclinical, chronic course which affects natural conditions for sheep (OIE, 2012). It is characterized by producing in the ram infertility, sperm abnormalities and secondary orchitis. In sheep, it interferes with pregnancy and retention of the fetus, causing reproductive failure, sporadic abortions, embryonic and neonatal death. In Patagonia the disease was first isolated in rams of Tierra del Fuego in 1963 (Robles, La Torraca, Sancholuz, Uzal, & Evans, 1993). The next section will study how the nanovaccine may increase productivity in the ovine sector, and which type of producer and geographic region would benefit from said increase.

3. A Brucellosis Nanovaccine as an Instrument for Social Inclusion

As it is mentioned before, ovine brucellosis is one of the major diseases of sheep in Patagonia. According to studies, about 60% of rural sheep breeding establishments have the disease, and it does not exist in the world a specific vaccine to prevent the disease, so the infected animal has to be sacrificed. After working for many years on the subject, finally, the National Institute of Agrotechnology of Argentina (INTA) internationally patented the first synthetic molecule that optimizes the prophylactic action of vaccines. The innovative technique is based on a molecule that allows to construct nanocarriers[4], which are routed to certain cells of the immune system to improve the efficiency of vaccines in animals.

Juan Sebastian Pappalardo (Animal Health Group INTA Bariloche, Argentina) was the leader of the project involving scientists from several universities. The patent in question is called "Compounds and Methods for Targeted Immune System Delivery"[5] and it was registered by Juan Sebastian Pappalardo (Escobar, Argentina), Micaela Toniutti (Udine, Italy), Stefano Salmaso (Abano Terme, Italy), Tatyana Levchenko (Revere, MA, US) and Vladimir Torchilin (Charlestown, MA, US). In vitro assays were performed in dendritic cells of different species, which proved the success of the molecule. Subsequently, with the Animal Health Group INTA Bariloche, which has the technology to produce antigens Brucellaovis, they began trials in mice and sheep. This vaccine could be a big key to attack sheep brucellosis, which is a contagious disease that affects the reproductive efficiency of sheep. Currently researchers are doing experiments in Pilcaniyeu province of Rio Negro (Argentina), with very good results. So this research and its results will contribute to the development of regional economies associated with sheep breeding.

If the government advances in the production and distribution of this nanovaccine, which type of producer will be benefited? To answer this, we should ask a subsidiary question. To which element of the value chain is the nanovaccine directed? The answer is provided in full by (Gatti, 2012) as the nanovaccine is directed at the same sector as the previously mentioned PROVINO program, which is the group of breeders and cottages in charge of genetics, and the breeding of animals for reproductive purposes. A technical inform of INTA claims that brucellosis should be wiped out of these establishments since the disease usually appears by buying an infected reproducer (Manazza et al., 2006).

This means that the vaccine is transversal to all producers as it is located on the very first stages of the ovine value chain. Nevertheless, if we ask the question of where would the introduction of the vaccine have the greater effect, we should note that the Patagonia, because of its extensive production modes, is the region with the lowest reproduction rates (Gatti, 2012) so the greatest ef-

[4] Nano-carriers are nanoscale elements that are introduced in the body and carry the drug to the place where the body needs it (Torchilin, 2012). To manufacture these products a patent is needed (Carbone et al., 2013).

[5] United States Patent Application 20150238621, Application Number: 14/431685. Publication Date: 27 August 2015.

fect would be located here. As we have said, both producers of type 1 and type 2 are located here. For the latter, increased reproduction levels justify themselves from the social point of view, and the increased productivity may let some of this producers reach the critical threshold where its production goes beyond its consumption capabilities (which would let them enter the market). For the former, poverty reduction achieved by the measure is to be moderate (as poverty is seldom prevalent on type 1 producers) unless the innovation translates on a higher demand for labor in the ovine sector. As type 1 producers are the heavier employers of labor in the sector, the innovation will have more profound effects as it increases exports and production destined to the local market, thus increasing employment of type 3 producers, this would in time, either increase employment levels in the sector, increase real wages, or both. In should be noted that, in any case, the effect on aggregate poverty measures will be small given the incidence of ovine stockbreeding on the country's income, in other words this is a micro-policy relevant to the objective population, yet prudency would dis-encourage any claims of spillover to other sectors of the economy.

It is hardly the case that a single organization undertakes a nano-medical project, usually joint investments are required. It is important to mention that the process of transforming patents into transactional goods starts with a process of singling out its properties, so it can enter the world of the business that uses it to produce nano-carriers. Once an interested company placed the patent into its network, the production process of the nano-carrier starts – which is then transformed into a good that would be exchanged by money in the market. However, there are clear asymmetries in the market, the future nanovaccine producer could be a large multinational pharmaceutical company. If this were to be the case, the role of the state in financing and regulating remains relevant, and its intervention justified.

4. Conclusion

This paper argues that a technical innovation (the development of a nano-vaccine against ovine brucellosis) can, through the productivity gains associated with it, change the behaviour of the heterogeneous beneficiaries of the innovation, most noticeably by encouraging many type 2 producers to transit from pre-capitalistic family-based self-consumption farming to simple low and medium scale farming for the internal market, and less notably, by increasing the demand for labor among type 1 producers. Thus resolving a social need, effectively reducing both rural poverty and urban-rural welfare differences in Argentina. In addition, the production of the nanovaccine is a highly effective state micro-policy that is contextualized, both in geographic terms, in terms of the objective population's social context, and in terms of policies historic performance.

Public policies must promote social innovation chains that have regional impact. On the one hand, it would achieve an immediate effect in helping counter ovine brucellosis in the Patagonia and in improving ovine production. On the other hand, it is a sustainable policy over time and it is coordinated according to the local productive and social dynamic. Future research will discuss the public and private incentives for this nanovaccine patent once it reaches the market.

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