Productivity and Agri-Tech in Uruguay

Challenges to productivity growth in agriculture and possible solutions

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Table of contents

Introduction

The following report starts by explaining the objective and methodology of the study carried out, considering its scope and limitations.

Next, it contemplates the definition of productivity and the reasons why productivity in the agribusiness sector is important. It also briefly considers the link between productivity and the environment. Before addressing the subjects of productivity, innovation and technology, there is an analysis of how productivity has evolved in the country's agricultural sector. Then the report focuses on understanding the obstacles that prevent the agribusiness from reaching higher levels of productivity, with an emphasis on agri-tech. Practical solutions and suggestions for further studies are also introduced. Before presenting the study's general conclusions, the report addresses the new situation in Argentina and its impact on Uruguayan agri-tech.

About this study

In May 2016 the British Embassy in Uruguay issued a call for studies including, among other subjects, an analysis of the agri-tech (agro-technology) sector. Sunny Sky Solutions, a national consulting firm led by Gabriela Castro-Fontoura[1], implemented this analysis for INIA (National Agricultural Research Institute).

*The **objective** of this research is to identify bottlenecks in productivity growth in the agricultural sector, with an emphasis on technological obstacles, and to suggest solutions.*

The study is focused on meat livestock, dairy and some crops like soy, sorghum, wheat and corn.

The **methodology** used included:

- a revision of existing literature concerning the subject of productivity and technology, and
- interviews to 35 experts chosen by INIA and the consultants.

What this research is:

- a consideration of the extent to which improvements in agri-tech can increase productivity in the Uruguayan agricultural sector;
- a first survey that gathers evidence from various organizations and specialists;
- a common ground for the vast existing literature on the subject, and
- an approach to subjects related to technology from a different angle.

What this research is not:

- a discussion on how to define and measure productivity in the agricultural sector and its subsectors;
- a study of the concept of agri-tech itself or of specific technologies;
- a historical, statistical or econometric analysis of productivity;
- an extensive survey of producers, specialists and various institutions, or
- an evaluation of particular institutions or programmes.

[1]Gabriela Castro-Fontoura is an Economics graduate from Durham University in England (BA Hons, Economics) and a business consultant specialising in Latin America.

The value of this study lies in:

- the consideration of the extent to which the lack of productivity growth in the agricultural sector, and/or specific subsectors, over recent years is due to technological reasons;
- the gathering of evidence from different organizations and specialists;
- the unbiased view of independent consultants who can provide a renewed and critical perspective;
- its dissemination in a clear and familiar language;
- its up-to-date approach and its significance, and
- its practical focus in pointing out what can be improved from now on and how.

We thank everyone who made this research possible, especially the experts who offered their valuable time, shared — with great humility — their vast knowledge and engaged in an open and positive dialogue we hope is reflected in this report. All the opinions herein are strictly confidential and of a personal rather than an institutional nature.

How do we define productivity in the agricultural sector?

As stated above, the objective of this study is not to debate the ways in which productivity in agriculture is understood and measured. However, establishing a clear definition to work with was a crucial step. Most experts interviewed defined productivity as:

output by production unit

In practice, depending on the sector, this usually means:

- kilos per hectare (livestock);
- litres per hectare per day or even protein yield per hectare or litres per cattle number (dairy), or
- yield in kilos per sowed hectare (agriculture).

To this we should add "respecting the environment:" it is very clear both in the interviews and the literature used that the *"sustainable intensification"* agenda (producing more while caring for natural resources) is well rooted within in the sector.

It can be clearly appreciated from both the interviews and the literature used that this is a simplified definition of productivity because:

- factors other than the land are not taken into consideration;
- among those factors not included, labour is critical and the experts who spoke on the subject understand that there is an important research shortage in this regard, and
- it was also mentioned that entrepreneurs* and their managerial capacity have not been correctly modelled as a scarce factor.

Another way of measuring productivity that was also discussed was total factor productivity (TFP). Bervejillo's work in this respect is considered as a reference in the sector.

* Translator's Note: The chosen translation of "empresario" as "entrepreneur" is intended to highlight the "business" side of the job, rather than any link to "start-up" or new venture.

"In short, in the past productivity was thought to depend on the factors of labour and capital. However, today it is recognised that its behaviour is shaped by a number of factors. Among them, the following ones stand out: investments, capital/labour ratio, scientific and technological research and development, installed capacity usage, governmental laws and regulations, machinery and equipment specifications, quality of human resources, trade unions and existing regulations, etc."[2]

Rather than considering matters related to a definition and production rates, which may be fairly technical, this study examines the extent to which producers measure their productivity or their income only. It is clear that if any type of productivity is measured, it will be that of the most expensive or scarce factor rather than that of all factors, especially that of labour, which is difficult to measure even for economists specialised in agriculture.

Why is productivity in the agricultural sector important?

There is clear and abundant evidence of the impact the agricultural sector has on the country's economy. The sector's relevance is not only due to its direct influence over the gross domestic product (GDP) but also because of its indirect influence over productive linkages (in agribusiness), employment and exports. The sector's multiplying effects are certainly well documented[3].

Given the importance of the sector for the country's economy, its productivity is significant because the bigger the gap between what is actually being produced and what could be produced, the more inefficiencies the general economy will suffer (in other words, if we could produce more with the available resources, we could in turn generate more income, employment, exports, etc.).

One of the productivity experts we interviewed pointed out that *"productivity is a very worrying subject because we have natural conditions and the necessary technology, hence, there is an untapped potential."* It is a matter of lack of economic efficiency: if the sector — which is key in a number of aspects such as foreign trade and productivity linkages with other sectors — is not taking advantage of its potential, then we are squandering resources. From another point of view, this means that if we could take productivity closer to its maximum potential, the sector would generate even more benefits within the sector itself and for the rest of the country's economy.

Yet, another fact to keep in mind — that applies more to some subsectors than to others — is that the sector's productivity is lower than traditional competitors like Australia and New Zealand. As stated by one of the interviewees, as long as our resources maintain a lower cost we may keep competing, but if the cost of resources rise and there is no growth in productivity our competitiveness will surely suffer.

There are also social reasons why productivity should matter. In the dairy sector, for example, one of the experts stated that 60% of producers produce less than 2,000 litres of milk per hectare per day (leading producers produce up to 15,000 litres per hectare per day). As a country, we aspire to improve these producers' quality of life and incomes by increasing their productivity and profitability.

One of the subjects addressed with several interviewees referred to the fact that many of the technologies used to increase productivity have the added benefit of making work in the countryside "less harsh," "easier" and "more humane." This is very important from a social point of view but it is

[2]Paolino, C.; Pittaluga, L.; Mondelli, M. 2014. *Cambios en la dinámica agropecuaria y agroindustrial del Uruguay y las políticas públicas*. CEPAL. Series "Estudios y Perspectivas". No. 15. Montevideo, Uruguay.
[3]Recommended literature: Uruguay XXI. *Informe Sector Agronegocios*. 2015.

also crucial from an economic stand point. On the one hand, improving production conditions will retain or even attract young workers to the countryside preventing migration to towns and cities, which is known to bring negative social consequences. Moreover, it was pointed out that these technologies often make it possible for women to undertake tasks that were previously pursued by men only. The incorporation of more young people and women diversify and enrich the countryside's labour matrix, making it more inclusive and sustainable in the long term.

Moreover, from a microeconomic point of view, as stated by one of the interviewees, *"increased productivity benefits all investments made in a company."*

Finally, in a world where food demand for an increasing population keeps rising and the pressure on available resources is heavy, the subject of producing more with the resources available not only affects individual countries but becomes a strategic matter at a global level.

It comes as no surprise then that two prestigious economists of the sector, Dr Ignacio Munyo and Dr Marcel Vaillant, addressed the subject of productivity in Uruguayan agriculture in a conference by the Centre for Development Studies (CED) at *Expo Prado* 2016.

Despite understanding that the sector's productivity does matter, we must make sure not to apply already obsolete productivist views. Increasing production with the available resources is not always good for the individual producer (and without the individual producer there is no aggregation possible). This research explores the reasons why increasing productivity (kilos of beef or litres of milk per hectare, for example) is a complex subject tied not only to technical or agronomic factors but also to social factors as well as individual/business decision-making and systematic aspects.

Productivity and the environment

When addressing agricultural productivity we must consider environmental care:

- on the one hand, increased production intensity brought about by an increase in productivity creates heavy pressure on natural resources and, if not handled correctly, it may damage the environment;
- on the other hand, the same technology used to increase productivity can also be used to protect the environment, as it may be the case with crop and pasture rotation.

"To a large extent, higher productivity may help overcome the opposition between production and environment." (Nicolás Lussich[4], about irrigation)

We found total consensus as to the understanding that increased productivity in the agricultural sector must always go hand in hand with the unconditional protection of the environment. This is clearly reflected in the concept of "sustainable intensification" that is commonplace in the sector.

This consensus is shared by producers (who understand that protecting their natural resources is profitable) and by scientists, experts, professionals, analysts, educators and politicians. We also found that the country is spearheading in the field of environmental protection. The law on agricultural land is a good example:

[4]Lussich, N. (October 2016). "*Aguas arriba*." *El País Agropecuario*. Year 22. N° 260. pp. 26-27.

"Recent agricultural expansion in the country requires that it be carried out using modern criteria for soil use, in view of the threats posed by erosion and the triggering of irreversible processes in the productive capacity of the soil. The Ministry of Livestock, Agriculture and Fisheries (MGAP, Ministerio de Ganadería, Agricultura y Pesca) has implemented a public policy which conditions entrepreneurial decisions in production management so that crop succession does not cause soil loss by erosion above the established tolerance for that particular soil. Soil loss estimation is based on the Universal Soil Loss Equation (USLE/RUSLE), a model resulting from over 20 years of national and international research. This integrates national capacities in institutional research and articulation in order to solve new dilemmas in agricultural development. This policy marks a difference between Uruguay and other countries in the region with regards to natural resources management and sustainability.

Again, this is about building a competitiveness platform based on the establishment of public regulations, which in this case are also aimed at a key factor in agricultural competitiveness at the international level: environmental and natural resources preservation as a condition for accessing the more demanding markets. Today, these developments require the creation and use of specific innovations (satellite farming, production systems based on precision agriculture that use state-of - the-art equipment) which could potentially allow a "just in time" agriculture, where it is possible to identify different nutrient levels in the soil for small crop areas in order to fertilize, use perfect herbicide dosage or develop harvesting plans according to said information."[5]

How has agricultural productivity evolved recently?

Numerous studies analyse the evolution of agricultural productivity in general and in various subsectors in particular. This study does not aim to replicate those historical studies but to focus on the present situation.

> *"... total productivity increased by 1.9% between 1980 and 2013. Over the last 10 years the annual rate reached 3%, although some recent symptoms signal a slowdown in productivity growth."*
>
> *Bervejillo J. and Bertamini, F., "Cambio técnico y crecimiento de la productividad total del sector agropecuario" in Anuario OPYPA 2014.*

Bervejillo and Bertamini estimate that between 2003 and 2013 the annual growth rate for meat and wool per hectare (productivity) was 1.29%, while that of milk per cattle number was 3.30%.

For the same period, the authors estimate an annual growth rate for soy of 3.08%, rice 2.19%, wheat 1.52%, barley 1.42%, corn 0.89% and sorghum 0.52%.

Even by estimating total factor productivity for the agricultural sector between 1980 and 2013, the authors demonstrate a "moderate and unsustained" productivity growth between 1980 and 2001-2002, with a strong growth during 10 years from 2001-2002. Since then, the authors claim that *"the relative slowdown in the sector's global TFP growth would then be linked to a slowdown in product growth in the more dynamic subsectors."*

Livestock is considered the less dynamic subsector, but according to the authors *"livestock's apparent standstill, mainly over the last 6 or 7 years, could have been a regression (negative growth) had there not been technical changes."*

[5]Paolino, C.; Pittaluga, L.; Mondelli, M. 2014. *Cambios en la dinámica agropecuaria y agroindustrial del Uruguay y las políticas públicas*. CEPAL. Series "Estudios y Perspectivas". No. 15. Montevideo, Uruguay.

"In sum, had the process of innovation in the agricultural sector not taken place, production would have been 46% lower." (As compared to 2000-2010)

ANII. *ENCUESTA DE ACTIVIDADES DE INNOVACIÓN AGROPECUARIA (2007-2009) (Survey on agricultural innovation activities)*.

By comparing the three subsectors covered in this research (meat livestock, dairy and certain crops), it is also clear that productivity gaps exist. There are few productivity studies by subsector. In the report quoted above, Bervejillo and Bertamini explain why it is so complex to disaggregate these figures by subsector, although it is understood that it would be very interesting to explore such differences.

It is also apparent that there are clear production gaps within each subsector. Some producers are producing very close to their technical potential (the maximum production that can be reached with the existing resources), while others are producing well below such potential. Our study focuses on this gap, since what is actually concerning is not the sector's current average level of production, but the productivity gap between producers within the same subsector.

Productivity, innovation and technology

This study focuses on the technological barriers to productivity. Without going into technicalities, it is important to explain what we mean by "technology."

According to Cambridge Dictionary, technology is:

"(the study and knowledge of) the practical, especially industrial, use of scientific discoveries."

Technology and science are linked by definition, and innovation is key for both to maintain their relevance[6]. Not all innovation is technological: this study focuses on technological innovation that has an **impact on productivity.**

Technology and innovation are, without a doubt, key to productivity growth. Technology adoption and the level of innovation vary within the sector, but evidence generally shows that producers are rational in their microeconomic decisions, and they innovate and adopt technology when convenient to them. The idea that producers (mostly in livestock) are conservative is not empirically demonstrated: producers innovate whenever they have (or feel they have) an incentive to do so.

[6]Recommended literature: definitions of innovation activities and innovation types in ANII. *ENCUESTA DE ACTIVIDADES DE INNOVACIÓN AGROPECUARIA (2007-2009)*. Montevideo, Uruguay.

"To summarise, the innovation survey reveals strong technological dynamism in the main agricultural export subsectors[7]. Most farming companies in those subsectors have incorporated innovation activities for the improvement of technological and organizational aspects. Additionally, there are high levels of innovative tendency — which reflect changes or outcomes resulting from the innovation activities carried out."[8]

"According to a special research by Consultora Seragro, commissioned by the Uruguayan Seed Chamber (CUS, Cámara Uruguaya de Semillas), the adoption of transgenic crops and its drive towards direct sowing account for one third of the economic growth in Uruguay during 2004-2015."[9]

"... it is interesting to see how, in the context of the Uruguayan economy, the agricultural subsectors are considered to have a high degree of technological content [...] ... regarding intensity and technological opportunity indicators, as well as the synthesis indicator itself, all agricultural subsectors are classified as high technology, or medium high technology subsectors" (Campo, D. "El contenido tecnológico de las exportaciones uruguayas")[10]

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[7]Such as the three subsectors considered in this research.
[8]Paolino, C.; Pittaluga, L.; Mondelli, M. 2014. *Cambios en la dinámica agropecuaria y agroindustrial del Uruguay y las políticas públicas*. CEPAL. Series "Estudios y Perspectivas". No. 15. Montevideo, Uruguay.
[9]Chartuny, E.; Magdalena, C. Ed ."*Manual de Agricultura de Precisión*". 2014. *Programa Cooperativo para el Desarrollo Tecnológico Agroalimentario y Agroindustrial del Cono Sur*.
[10]Anuario OPYPA 2014

What barriers are preventing productivity growth in Uruguay?

According to the interviews and sources used in this study, the main obstacles that prevent productivity growth in the farming sector can be classified in the following categories:

- agri-tech barriers;
    - extension, dissemination, transfer and adoption barriers;
    - business management barriers;
    - knowledge management barriers;
- natural barriers;
- profitability-linked barriers;
- contractual barriers;
- financial barriers, and
- public policy barriers.

It is important to stress that these barriers could be both "real" (scientifically proven) and "perceived" (not based on evidence/studies or even contrasted by evidence).

Agri-tech barriers

Technological barriers (linked to inputs and processes) are the focus of this study. As shown below, there are specific technological barriers for each subsector.

Agriculture

In the case of agriculture, there is a strong improvement in productivity and "producers are using the whole technological package."

The specific barriers mentioned were:

- the availability of varieties and genetic material;
- problems with the performance of wheat, with pests that break disease resistance in some varieties;
- problems linked to water excess in winter crops;
- in the case of soy, the amount of water that can be stored in the soil — which is insufficient for the growth cycle and was mentioned as a limiting factor.

It was also stressed that being at the forefront in productivity issues requires involvement in a constant scientific and technological race.

Livestock and dairy

In both subsectors, we found:

- producers whose productivity is nearly reaching its potential and are large technology consumers;
- producers whose productivity could be greatly increased by implementing proven existing technological improvements, and
- producers whose technology adoption is very basic and limited.

In connection to both livestock and dairy, the literature consulted and the interviews carried out point towards a consensus that the technological barriers are minimal ("the technology is available") but the actual obstacles:

- relate to dissemination, extension and adoption (see below), and
- do not relate to technology but to other kinds of issues such as public policy or market incentives (see below as well).

Some interviewees considered that there is a lack of "technological certainties" or "technological track records" both in the dairy and in the livestock subsectors. By "certainties" or "track records" they refer to "manuals" for proven, safe and reliable technologies ("how to produce more with what I have"). However, views are polarized. Some consider that, technically, both producers and technicians know how to increase productivity but this is not achieved anyway (due to the barriers considered below). This polarization indicates that, surely, if the technological track records or certainties actually exist, they are not being communicated throughout the sector.

Extension, dissemination, transfer and adoption barriers

Clearly, the fact that there is a local supply of relevant technology that meets certain conditions (low cost, certainty, simplicity, etc.) is not enough: technology must reach each producer.

This includes issues of technology dissemination (making it known) as well as extension/transfer (applying it on the field). Extension and dissemination do not depend on the producer, who is a passive receiver of the latter and an active receiver of the former. The third issue is adoption, which depends directly on the producer.

This study focuses on all three subjects of dissemination, extension and adoption because agri-tech does not reach the producer by itself: dissemination and adoption are thus critical.

So, are there flaws in agri-tech dissemination and/or extension? Some consider that agri-tech extension and dissemination is very limited, while others consider extension is even excessive and, therefore, there is too much information.

In general, it is understood that larger producers have less extension problems than smaller and medium-sized producers because they already have a proper internal structure (even with technology/knowledge leadership), they have less risk aversion and more financial resources to invest in technology.

Therefore, extension is a barrier mainly to smaller and medium-sized producers.

As to the quality of extension, all sources agreed that — with the exception of FUCREA — dissemination of economic analyses regarding specific technologies is very limited (this does not mean that such analyses are not done, but that dissemination is perceived as not being enough or not done in the best ways).

"Everything related to agriculture is too segmented in Uruguay," an interviewee stated. This was a recurring view regarding technology dissemination and extension. It was found that the scope of each agricultural institution is not clear to producers or other actors; there is great confusion as to who is responsible for what regarding extension. This issue will be addressed below in relation to the importance of institutional improvements in the sector.

Business management barriers

Business management continues to be a technological barrier in connection to processes and, as such, it is key to this study. Both from the literature and the interviews, it clearly emerges that one of the primary barriers to productivity growth is the lack of **business management skills**:

- there is a lack of human resources management (internal and outsourced);
- economic, administrative and financial management fails;
- there is *"limited human capacity to create companies"* in the country;
- generally, long-term entrepreneurial vision is limited, and
- there is also a generational issue, where those in charge of decision-making/management are older (younger people are generally more willing to make changes).

These barriers are more noticeable in livestock than in agriculture, where there have been significant improvements in management over the last 10 years. Within livestock, it is particularly evident in meat livestock breeding.

However, it was noted that business management shortcomings are *"a matter of attitude"* rather than size, as there are excellent smaller producers who are constantly pushing the envelope.

In this respect, an interviewee stated that:

"A change of mindset is needed; there is a need for an entrepreneur new to livestock."

This interview also added that much of the know-how in agriculture came from Argentinean entrepreneurs or Uruguayan entrepreneurs from other sectors.

The reason why these management barriers exist are beyond this report. However, it is interesting to ask ourselves why agricultural and especially livestock entrepreneurs do not change their organizational structure in order to increase productivity. Various experts interviewed agreed that an increase in productivity is often not worth the structural change. For producers, "their numbers" are not worth the — complex — technological change in management. There is also a generation matter that contributes to the *status quo*, and a limited thrust from other sectors or countries.

Why, then, is it so difficult for a certain type of entrepreneur (especially in livestock) to make changes in business management? It was stressed that in order to adopt new technology for the purpose of increasing productivity:

- it is not always necessary to employ less labour, but it is always necessary to employ people with a different profile and this implies higher wages (which are justified precisely by an increase in productivity); these estimations and vision are not simple or lineal;
- the benefits are not reflected in the price received but, for instance, in reduced risks (hiring a vet can reduce sanitary risks, for example);
- very often the benefit is a better quality of life in the countryside, thus attracting more and better suited employees that may wish to settle down there;
- many times, the benefit translates into available time to "do the thinking" in order to produce better;
- other times, it allows for spare time to dedicate to other "entrepreneurial activities" or even valuable family time, and
- risks are significant, as it is never 100% certain that changes will lead to an increase in productivity and/or profitability.

In other words, the benefits of a change in management are not clear, obvious, lineal or immediate and producers with a certain risk aversion will prefer to maintain their *status quo*.

Knowledge management barriers

Just as it happens with business management, knowledge management is also a matter of process technology and, therefore, it is key to this study.

"Improvement in productivity and production conditions attracts investments in the sector, which in turn increase land income and contribute to improved productivity. Increased productivity is a consequence of the increased use of inputs, equipment and services purchased from the economy's non agricultural sectors. Under these conditions of increased use of inputs and services and a greater interaction with markets, management practices become more complex and consequently require more human resources skills and capacity. This context – increased productivity, greater use of inputs and services and greater complexity of management processes – favours the training and specialization of human resources and of the equipment in the different segments of the value chain, which become more diverse and complex to manage."[11]

Interviewees also agreed that it is not easy to introduce agri-tech because it involves a medium to high risk, particularly when experience and training in the management of such knowledge are limited. Some even stated that, due to the multitude of production models available, it is difficult to "copy" or "adapt" technology without the necessary skills. One of the problems underlined as a consequence was the wrong adaptation of technology or "half-adaptations," where the benefits of a good adaptation are not visible while the risks and costs remain.

At the company level, small and medium-sized producers in all subsectors face this knowledge management barrier. There is an abundance of products/inputs, ways of doing things/processes and information, but very limited time and skilled staff to analyse these. Investing in and adopting agri-tech results in a more complex system, since it will likely be necessary to invest in specialized labour and changes in management.

To summarise, in the words of an expert interviewed:

"A simpler rather than a more productive system is often preferred."

This is partly the case with irrigation, which is mentioned throughout the report. Including irrigation in a production system involves not only a certain cost but also a "complication." *"Irrigation cannot be applied to everything; that much is clear. If I irrigate only 5% of my crops, the impact is limited and I have complicated my entire system,"* a dairy expert explained.

It is worth noting that when reflecting on automation (one of the technologies that increase productivity), an expert interviewee said it allows more time for producers to "do the thinking" and that is when, not immersed in the issues of daily operation but in more strategic matters, they can think about productivity. Thus, one of the barriers found is the limited adoption of automation. This expert focused specifically on the limited adoption of more complete milking equipment.

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[11]Errea, E.; Peyrou, J.; Secco, J.; Souto G. 2011. *Transformaciones en el Agro Uruguayo. Nuevas Instituciones y Modelos de Organización Empresarial.* Universidad Católica del Uruguay. Montevideo, Uruguay.

Particularly in livestock, it was highlighted that producers often make decisions that seem technical based on issues not related to productivity. For example, it is not uncommon for producers to choose cattle breeds not based on its performance or adaptability but on family tradition.

The interviews led to a discussion on "low cost" as compared to "high cost" agri-tech. Some also believe that "low cost technology does not exist," particularly if taking into account the opportunity cost or the cost of the increased complexity of the productive system.

If proven, simple, low cost technology does exist, then, it is worth asking: why isn't it more and better adopted by producers? These are some of the explanations gathered:

- a very relevant explanation is that producers do not always aim to increase production, productivity or even profitability; this is not their only concern when making decisions. There are other variables that producers take into account, like their spare time and their quality of life — adopting technology takes time and energy, it implies "doing the thinking," and producers are not always willing to invest their time and other intangibles on the improvement of productivity; they value "not complicating things;"
- risk aversion, and
- other barriers that are not strictly technological, which are explored below.

Natural barriers

Among the natural barriers to an increased productivity, the most commonly mentioned one is climate variability:

"We are located in one of the regions with greater climate variability in the world, driven by (an already observed) climate change and a likely increased frequency of extreme events — like drought —, which has an impact on farms' productivity, incomes and costs, thus threatening their sustainability. In countries like Uruguay, these factors strongly impact macroeconomic variables, employment and exports, therefore affecting the entire society."[12]

Authors who have studied matters of innovation in the sector more in depth[13] have also pointed out that *"Climate variability is, on average, the most frequent obstacle for the development of innovation activities in most subsectors."*

The most prominent natural barrier — climate variability — explains only in part the limited investment in agri-tech in order to improve productivity, given that much of the current and developing agri-tech (from irrigation to precision agriculture) is specifically aimed at mitigating the impact of climate variability.

There was also mention to soil variability, which is why it is difficult to generate processes, protocols and standards that could be applied throughout the country.

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[12]FAO; MGAP. *Clima de cambios*. 2013. *NUEVOS DESAFÍOS DE ADAPTACIÓN EN URUGUAY*. *Resultado del proyecto*: *TCP/URU/3302 Nuevas Políticas para la Adaptación de la Agricultura al Cambio Climático*. Montevideo, Uruguay.

[13]ANII. *ENCUESTA DE ACTIVIDADES DE INNOVACIÓN AGROPECUARIA (2007-2009)*. Montevideo, Uruguay.

Profitability-linked barriers

Productivity alone is not enough. If by improving physical productivity, producers do not see a profitability increase (if their investment does not generate profits at least equivalent to their investment, including their invested time), it seems quite rational for them not to be interested in increasing factor productivity. This came up repeatedly during the study. Again, it is necessary to highlight the importance of understanding producers' profitability in order to grasp why they decide not to increase productivity. Producers cannot be expected to take risks in technology investments aimed at improving productivity if they do not see a return on investment translated into higher profitability. A productivity based analysis and a purely technical motivation to increase productivity are not enough: we must understand that producers consider their economy rather than their technical productivity. "Economy" does not refer here to their profits only (to their "finances") but to all the factors involved in a decision of an economic nature, from the value of their time (family or spare time, for example) to the economical value of "not complicating things."

In order to address this matter, we must first understand the impact of calculations, risks and perceptions:

- producers must be able to calculate, *in a simple way*, whether a certain technology could yield financial results — if this is too difficult to calculate, they will not invest;
- showing producers how a technology improves productivity (more kilos per hectare, for example) is not enough — they need to be shown how one dollar invested in that technology produces incomes above that one dollar;
- understanding production as a system is the critical point — if the one dollar invested for higher performance also generates important complications and complexities that will alter the system or demand much time from producers, they will often choose to maximize simplicity or convenience rather than financial return, as mentioned above in relation to business management and knowledge management barriers;
- the more risk aversion producers have (whether existing or perceived risks), the more likely they will be to maintain the *status quo* and not invest in agri-tech;
- the stronger, more consistent, longer term and clearer the incentives to invest in agri-tech, the more likely it will be for producers to invest, because incentives will outweigh their risk aversion, and
- the more producers value other economic benefits (like spare time or "not complicating things") rather than strictly financial benefits (like profitability), the harder it will be to persuade them of investing in agri-tech in order to increase productivity – the arguments in this case should focus on the fact that technology may provide spare time, peace of mind, rest and other benefits apart from a strictly financial return.

One more aspect to be considered is that the calculation of the benefits producers obtain from investing in agri-tech cannot be isolated from other factors affecting that return, namely:

- the market, and more specifically, the market price ("what if I invest one dollar, then prices fall and I can't even cover the investment?") or demand for their product ("what if I invest one dollar and my buyer doesn't purchase my whole production or exports go down?");
- macroeconomic conditions like rate of exchange or trade openness;
- costs that the producers have to deal with which affect profitability — especially in livestock, a recurring phrase was *"the livestock producer would rather spend less than produce more;"*
- risk aversion, and
- the human resources and agronomic complexities inherent in a system.

What is repeatedly observed is that many producers do not feel confident about the relation between physical productivity and the price they obtain for their products. This is why keeping costs low is more important than increasing productivity, particularly in livestock. Likewise, producers often consider best not to increase productivity, but also not to increase costs and risks.

In many cases it was illustrated how, with the right price incentives, agri-tech (and therefore productivity) investment does take place. This shows that there is no real resistance to change, that when it is actually profitable producers will invest, even against the risks inherent to the sector (climate variability, international price variations, exchange rate variations, etc.). The clearest example mentioned was the case of the 481-quota: such differential payment justified the investment and took precedence over all other barriers addressed in this study.

This is partly the justification of the vision that "demand is the main driver" and producers will increase productivity as long as there are positive signs from the market.

On the subject of the "market," there was mention to livestock producers' lack of trust in the meat chain. Many livestock producers consider that abattoirs (frigoríficos) set the price, or quantity, of their products, so investing in productivity improvements is not justifiable if, at the end of the day, these plants will not reward them or will even drop the price making the investment in producing more kilos per hectare not profitable. Regardless of whether this oligopolistic behaviour by abattoirs really exists (scientific evidence on the matter varies), what undoubtedly does exist is the *perceived* notion of many producers and other actors in the sector that it exists, and this affects decision-making.

Contractual barriers

Some interviewees, both in dairy and meat livestock, stressed the fact that land lease terms are too short and do not stimulate technological investment.

Financial barriers

It was highlighted that for the bigger technological leaps, which cannot be accomplished with management changes but with changes in inputs (robotics, genomics, big data, etc.), larger investments are needed and there is a lack of long term credit. According to experts, this is particularly important in dairy, where automatizing a milking yard or irrigating improved pastures requires an investment of tens of thousands of dollars.

The examples of competing countries like New Zealand or Australia were mentioned, where financing is for a period of 20 years, while in Uruguay is for a period of only 4 years. It was also mentioned that in New Zealand 300 cows are milked per person, while in Uruguay it is 60 cows per person. There are few studies on production *per capita*. According to an interviewee from the sector, a milking yard can cost up to 100,000 dollars but there is no long term financing. The same interviewee added that there is no financing for housing repairs to improve farmers' quality of life. Then, making land available to young people so that they can start a dairy farm is not enough, because they will "get off to a bad start." Financing is also an issue in irrigation, where a pivot costs up to 100,000 dollars and requires expensive hydraulic engineering. There was mention to the importance of irrigation in building productivity and stability, but its role in building profitability was questioned.

According to two experts interviewed, one additional problem is that short term financing leads to technology "not being applied properly" and growth not being as foreseen.

Producers' and their consultants' financial education was also identified as a barrier to be overcome. Aversion to debt was also mentioned, for historical (crisis) and cultural reasons (applicable to many other sectors, not just agriculture).

The lack of comprehensive and development insurance schemes — other than insurance schemes to "overcome crises" — was mentioned. We understand there have been significant advances in insurance schemes for the sector in the last five years, but it seems they are not always well communicated to producers and experts.

Public policy barriers

Public policy barriers are beyond the scope of this study, but they were highlighted as key by numerous interviewees and in various reports, considering them to be even more important than agri-tech barriers when addressing the lack of investment and productivity growth.

The **lack of trade openness** was identified as one of the most significant barriers since it negatively affects producers' margins, prices, volumes and, therefore, incentives to productivity increase.

A **negative business environment**, particularly for livestock, was also mentioned by those who maintain that:

- livestock farmers face constant threats, such as withholding tax;
- a land tax the government had promised not to introduce;
- a specific tax for land owners to contribute to State education that is considered unfair;
- constant taxation adjustments that create insecurity and distrust;
- bureaucracy that creates costs (financial and economic, related to time lost in administrative transactions and procedures), and
- infrastructure issues which act as a key barrier by adding significant costs to the sector.

The **weight of the State** is clearly a barrier to the sector. The importance of this barrier is seen differently by different interviewees. Some had very pragmatic opinions: *"It's part of the game and the agricultural entrepreneur must accommodate it."*

It has already been established that profitability is key to improving productivity. Production costs are a factor in profitability, and in Uruguay they are considered to be very high, in particular:

- the cost of energy, which negatively impacts the adoption of irrigation, for example;
- internal freight, compounded by the price of fuel and the inadequate conditions of roads and motorways, and
- the bureaucratic cost of a heavy State structure.

Clearly, there is room for public policies that can make production costs more competitive at an international level.

How can productivity be increased in the Uruguayan agricultural sector?

Below are some suggestions to help overcome the barriers mentioned in the previous section. They have been grouped as follows:

- improvements in agri-tech;
    - improvements in technology supply;
    - improvements in information technology;
    - solutions to stabilize production systems;
    - the issue of irrigation;
    - improvements in management;
    - improvements in extension;
    - suggestions for research;
- improvements in public policies;
- financial improvements;
- institutional improvements, and
- other improvements.

Improvements in agri-tech

Technological solutions, which are the original focus of this study, were found to enjoy the broadest consensus and to offer most possibilities for action and achievement of positive results in the short and medium term.

It is generally agreed that there is no lack of technological supply. The technology that producers need and/or want is available.

It is generally understood that there is a certain bias towards input technologies because there is always a manufacturer interested in their introduction. Management or process technologies are more difficult to promote.

There is also a general consensus that Uruguay is diverse when it comes to technology, with very advanced producers that employ "state-of-the-art" technology while others use little and very basic technology.

This is not necessarily considered negative. On the one hand, it means that "if some are doing it, and doing it well, then it is possible." On the other hand, it means there are certain reasons why some are not doing it. We will look into them below.

There is much debate around the issues of access to technology on the one hand and extension on the other.

The subjects of dissemination, extension and adoption will be addressed later. Regarding *access*, some consider that, even where the technology exists, it is too expensive for many producers (especially for smaller producers, like smaller scale sheep and dairy farmers). The technology is actually available and understood by farmers, but it is still inaccessible (irrigation, for example). This is linked to the above mentioned financial barriers.

However, other matters we have already addressed come into play as well:

- where the price of the agricultural product justifies it, many consider the technology would be acquired because the profitability obtained would justified it; so the key is in production costs;
- many others understand that access is hindered not by the cost of technology but by financing issues; therefore, the key to increasing productivity is the availability of longer term credit, and
- others argue that it is a matter of attitude towards risk, a generational issue (which could be solved as more young people take managerial responsibilities), and even a matter of financial education in the subject of debt.

As pointed out earlier, there was total consensus in that rural producers from any of the subsectors studied are open to technological change and technology adoption — if and when they consider it will increase profitability. Producers do not refuse to adopt technology; it is actually quite the opposite.

Improvements in technology supply

Although the productivity issue is not generally related to a lack of technology supply, there are some exceptions. In this regard, the literature used and the interviews carried out tend to show there is room in the Uruguayan agri-tech market for the following improvements:

- more and better information about genomics;
- continued genetic improvement, and
- in the case of agriculture, new events and more recent, greater value varieties (germplasm);[14]
- extension in robotics and automation;
- a better understanding of big data in decision-making (for instance, in precision farming and cattle traceability);
- agri-tech associated with compulsory traceability (in order to maximize the effort producers make);
- water efficient agri-tech;
- agri-tech focused on mitigating the impact of climate variability (related to forage and irrigation, for example);
- tools for the control of parasitic infections, and
- technologies that make an efficient use of renewable energy, particularly in irrigation.

The following studies in agri-tech were also suggested:

- natural pastures for livestock and dairy;
- improved fields (what species adapt better, rotation, composition, higher dry matter yield, etc.) in dairy production, and
- dairy and livestock breeds that adapt to our pastures (understanding the genetics and productive potential of each breed) — this is especially important in meat sheep, as the transition from wool breeds to meat breeds is still complex.

[14]Seragro. (August 2016) "*Impacto Profundo*." *El País Agropecuario.* Year 22. N° 258. pp. 20-23.

It is also important to highlight that, since technology is constantly evolving, local actors — especially those who act as advisers to the producers (including INIA) — should be permanently up to date. In this respect, highlights mentioned were the agreements entered into with foreign universities and the continuous training of INIA's scientific team, which is highly prestigious within the sector.

As shown in previous studies, we found what low productivity producers lack the most is process technologies.

For a large majority of producers, any technology (input or process) must:

- be easy to adopt;
- have a high and measurable impact in productivity;
- be low cost;
- be low risk;
- take into account the system as a whole, and
- not add complexities that could alter the dynamics of a production system considered from a holistic point of view.

This applies to producers who are producing below their potential levels. Having said this, the technological needs of leading producers should not be overlooked, as they are the ones driving innovation in the sector. These are the producers who will benefit the most from specific leading agri-tech that will help them reach their production potential. And they are also the ones who need to constantly incorporate new technology. However, because these producers are generally better at managing knowledge and innovation, improvements should focus on building a context for innovation (instead of barriers), so that they may continue innovating and remain an example for producers who are less advanced in terms of productivity.

Improvements in information technology

Given that experimental research in each scenario is not possible and that the scientific and actual dimensions do not match due to the systemic complexities of the latter, some suggested improvements include:

- simulation models that help interpret the enormous amount of data, especially in the long run. As opposed to the compartmentalized dissemination of information by speciality or institution, a more holistic approach is needed so that decision makers (from producers to the sector's Minister) may do their job;
- training in "applied system analysis," simulations and big data.

There was also mention to "turning data into questions" rather than communicating data just as data — the aim is to solve a problem, therefore, information should be communicated as a solution to a specific problem.

In this regard, the initiatives highlighted were Expo Prado's *Hackathon* organized by the British Embassy and CPA Ferrere's *Emprendetón* — both held this year —, which manage to "bring together the countryside and the city" and enable contributions from the Uruguayan ICT sector to the agricultural sector.

Solutions to stabilize production systems

As mentioned before, climate variability is an indisputable barrier. Thus, the solution is to build stability in production systems "so that there are no bad years."

It is stressed that weather forecast and satellite monitoring technologies are necessary to stabilize forage production and increase predictability.

Below we will see how irrigation also plays a role in the stabilization of production systems.

The question of irrigation

During the course of this study the "irrigation law" was being considered by Parliament. We believe it would be an agri-tech improvement towards productivity and production systems stabilization; therefore, we consider important mentioning the opinions and suggestions of the experts interviewed on the matter of irrigation, since — should the law be actually passed— they would prove to be very valuable contributions.

Discussing the irrigation law and irrigation in general polarized the opinions of interviewees, particularly taking into account our approach in terms of productivity.

There was consensus with regards to the notion that irrigation is a positive technology when it comes to increasing crop productivity, including pasture. There was also agreement on the idea of irrigation as a safeguard in the face of climate variability. Diverging opinions referred to the law itself, its application and profitability rather than its technological aspects.

The importance of irrigation in acting as an "insurance" by creating silo reserves in irrigation responsive crops was emphasized in several interviews. The irrigation of pastures was generally ruled out as a profitable option.

"... the introduction of irrigation as a way of increasing productivity and minimizing risk became a more attractive strategy than the expansion of the surface used" (about changes in agriculture since 2007)[15]

"No agricultural activity to date has scored as high in an investment project evaluation as irrigation systems have" Minister of Livestock, Agriculture and Fisheries, Agricultural Engineer Tabaré Aguerre.[16]

In "*Perspectivas Agropecuarias 2016*" (Blasina y Asociados), Minister Aguerre explains that the number of pivots grew from 28 in 2010 to 350 at present. Concerning the "irrigation law" he builds on the idea of "water investors," not unlike the case of wind power, although he admits this would not happen countrywide. The importance of irrigation beyond productivity as explained by the Minister in the mentioned publication is the following:

"Irrigation will not only mean more productivity, because a positive carbon balance will also allow for productivity plus more stability and sustainability [...] Uruguay will then be at the forefront as a

[15]Carriquiry, M.; Gaudioso, R.; Mordecki, G. *et al*. 2015. *Hacia una economía verde en Uruguay: Condiciones favorables y oportunidades.* Economía Verde.
[16]In Blasina y Asociados, "*Perspectivas Agropecuarias 2016.*"

country developing by improving efficiency in terms of greenhouse gas emissions per food unit produced."

Issues regarding how effective the implementation of the "irrigation law" — rather than irrigation itself — could be mainly focus on:

- understanding, for example, who pays for a reservoir;
- understanding what other laws are linked to the irrigation law;
- collective management, governance and organization of irrigation, and
- understanding the return on investment, not just of the financial investment but also of the increased management time and complexity of the system.

However, the main reason for the clear scepticism when addressing the subject of productivity is the idea that the irrigation law will not "change things," that there is "a lot more to be done before irrigation."

Improvements in management

Particularly in livestock, many experts claim that productivity could be considerably increased by relatively simple, low risk, replicable, *proven* and low cost technological changes. Among these, the following known changes were mentioned:

- adjustable load;
- early weaning;
- crop and pasture rotation and management;
- herd and breed management, and
- strategic supplementation.

In order to stimulate the adoption of these improvements in production management, better extension and communication of the economic improvements are needed. *"Producers already know that this is what they have to do. If they don't do it, it's because of its low profitability or complexity,"* therefore, it's important to share the information about the economic and technical benefits of these improvements.

Improvements that have to do with business management are more complex and always relate to financial and business education. Just like (free) training for numerous services and industries is available in the cities, the improvement and increased availability of business training for rural producers/entrepreneurs is recommended. It is important to provide training in:

- business education;
- management and decision-making education;
- finances, especially in the subject of credit and debt (when and when not to take out a production loan, for example), and
- human resources management.

Improvements in the dissemination, extension/transfer and adoption of agri-tech

As expressed earlier, extension is still a controversial subject. Focus is now shifted to fields where there is a consensus in the suggestion of improvements.

There is consensus that producers, rather than knowledge itself, need to know what the benefit will be for every dollar invested.

Again, communicating not just the productive but also the economic benefits is of paramount importance.

There is consensus in that the communication of scientific and technological information must be improved.

One of the central conclusions of this study is the need to improve the way scientific and technological information is communicated to producers, as well as within the sector (agronomists, veterinarians, scientists, politicians, economists, consultants, analysts, etc.). It is not a matter of more communication but of better, more relevant, brief and enjoyable communication.

To summarise, in the words of one of the interviewees "technology itself is half the work, the other half is telling the story, **communicating** the solution (and the problem) is almost as important as the solution itself."

There is consensus that the best way to exercise extension is by "going out there, on the field."

It is suggested, as a practical improvement, to evaluate and rethink previous extension efforts and to focus agri-tech extension from a more scientific stand point (supported not necessarily by scientists but by educators and communicators). In this context:

There was complete consensus in that the CREA model does increase productivity.

Thus, we suggest reviewing ways to support this model (for instance, supporting the expansion of CREA groups without altering their values or processes, which make the model unique) or ways to replicate them in a financially sustainable way (this has been attempted but there might be a lack of economic evaluations of these projects and programmes).

There is also consensus that extension prompted by the supply does not work and it must be demand-driven.

Therefore, improvements in communication are considered to be essential, not simply by intensifying the use of graphics and infographics (which is recommended) but by adopting communication models that adapt to the producers' reality. Extension is supposed to solve problems instead of "overwhelming" producers or their advisers with information. In this regard, UPIC's work method was commended.

There are discrepancies in the subject of which institution should lead the matter of extension. The evaluation of specific institutions is not one of the objectives of this study. However, it is clearly necessary to define the scope of each institution (simply put: what each institution does, what needs it meets, with what budget and how institutions work together). The lack of understanding about the scope of each agricultural institution in the matter of extension came up repeatedly in the interviews. This prompted criticism of some institutions which exceeds the objective of this study. The value of a more practical and clear method of communication (a simple diagram with the use of

graphics and little text like the popular "infographic") is suggested in order to explain the following to all actors, internal or external to the sector:

- which institution covers which area of technological extension (geographically and by subsector);
- the number of staff available for extension (in order to adjust expectations);
- the budget assigned to extension (in order to adjust expectations), and
- interactions with other institutions.

It is worth mentioning that even though experts, producers and other actors within the system are not always informed on these matters, internally, each institution has clear guidelines with regards to these. This is also relevant in order to understand institutional scope beyond specific individuals, to provide sustainability to the system and continuity beyond specific managers or technicians present at a given time.

The role of Conaprole in the subject of extension and industry-producer operations in the dairy sector is also worth mentioning. There is a similar institutional involvement in the rice sector but not in the meat livestock sector.

One of the interviewees mentioned the 2016 National Technology Plan with the support of various institutions in the sector. Reconsidering this initiative is key. As expressed by one of the interviewees, the first step, which bears no cost, is to integrate all institutions. The second step is to create a sustainable model. In the third place, the redirection of funding from certain international organisations in order to hire more extension workers is an essential step towards giving new thrust to the National Technology Plan on the basis of this study.

It is clear that there is a need for a national technological transfer system but there is a lack of public financing. Therefore, we suggest:

- providing external support for FUCREA (funding from the Inter-American Development Bank, IDB, or foreign governments, for example) to promote the dissemination and adoption of the CREA model among producers without compromising the organizations values and ethics – this could be an excellent way of "leveraging" the creation of a publicly funded private organization dedicated to the livestock sector without overloading public administration;
- defining and communicating the scope of the sectors' institutions with regards to technological extension, and
- reconsidering resuming the National Technology Plan.

The subject of improvements in extension is a clearly fragile, complex and highly sensitive issue that involves various institutions. This issue is known to most of the actors within the sector. We believe it is time institutional barriers are finally overcome (both inwards and outwards in each institution) in order to offer agricultural producers better extension services, with leading and interacting institutions where extension is not "just one more aspect" but rather a key inherent role. With regards to INIA, as already expressed by an evaluation published in 2011[17]:

[17]INIA; IICA. 2011. *Evaluación de los impactos económicos, sociales, ambientales e institucionales de 20 años de inversión en investigación e innovación agropecuaria por parte del Instituto Nacional de Investigación Agropecuaria*. Uruguay.

"The articulation of technological transfer constitutes an unsolved dilemma for INIA which is — for many external and internal actors — one of the major weaknesses in institutional performance. This weakness does not help to appreciate and strengthen the research effort made.

INIA has historically emphasized its role as a research institution. This is clear in an organizational structure where the whole institution is built around programs and projects. INIA has never had a unit, component or program dedicated to knowledge management. Within INIA the information is not systematised and there is no management program dedicated to the conversion of data into information and knowledge, and the creation of mechanisms to access and share information (interactive website, communities of practice, etc.). Its institutional mandate, however, includes two more areas apart from research: the articulation of technological transfer and the management of technological knowledge in agriculture. This has technical, managerial and budgetary implications.

INIA has accumulated over 20 years' worth of scientific and technological knowledge in agricultural subjects, plus what it has inherited from previous public institutions, research, development and innovation activities, Instituto Fitotécnico and CIAAB. There is a large amount of data, information and knowledge lacking organization, systematization and eventual dissemination."

Although the INIA scientific team was highly commended, it is still considered there are issues regarding timing (producers must make faster decisions) and scope (scientific scope is not in tune with the producers current situation and the holistic handling of the system). In this respect, since the focus of the Instituto Plan Agropecuario (Agricultural Plan Institute) is precisely the system as a whole, emphasis was made on the recent rapprochement between both institutions and this collaboration effort is expected to continue.

Suggestions for studies

This study is limited to a first exploration of only three subsectors. We believe more research is required, not in the field of agriculture itself but in agricultural economics and even with contributions from other disciplines like communication and sociology. Below is a combination of suggestions drawn from the study itself and those found in the literature and from interviewees:

- several interviewees stressed the importance of better understanding the productive potential, the "frontier" or "optimal biological results" of different systems as well as the "optimal economic results," while always taking care of environmental sustainability;
- the economic impact of different technologies should be explored;
- a deeper examination of the subject of this study is needed, an analysis by specific subsectors (those analysed in this study and others like farming, forestation and wool);
- a (sociological/economical) study of the producers themselves and their productive barriers (real and perceived, including personal, family and economical barriers) would be valuable;
- a continued effort in the study of labour productivity and other production factors is suggested;
- a better evaluation of silvopastoral systems was suggested;
- more studies in all subsectors about the current and future requirements of international markets is suggested, especially with relation to carbon footprint, water footprint, animal wellbeing and social footprint; some of these studies are only emerging in the country, to foresee demand;
- a study that summarizes how to communicate and perform extension with specific examples of countries which are considered exemplary in the sector like the United Kingdom, the

United States of America, New Zealand and/or Australia in order to learn from their experiences in these areas;

- carrying out scientific studies about the flow of entrepreneurs from Argentina, New Zealand (in dairy) and Brazil (in rice) into Uruguay and the impact this could have on the country. This is because "it is proven that the greatest impact on technological development processes comes from the movement of human groups that carry innovation and culture with them, rather than from long and costly training processes," and
- one of the documents analysed[18] about the technological content of the country's main exports provides an interesting proposition; we suggest research is carried out on this subject, which would connect other more complex subjects regarding economic development.

Also, "*It is suggested that the indicators presented by Bervejillo (2013) referring to kilos of meat per hectare of pasture land per cattle unit, and total livestock unit per hectare of pasture land be given continuity. In addition, annual indicators for irrigation area in the agriculture and livestock subsectors are not currently available either per year or activity.*"[19]

The above mentioned assessment also suggests other kinds of research that bear a connection with the institutional improvements mentioned in this report:

"INIA must organize an information system and database that will allow periodic productivity readings in the agricultural sector at a national and regional level to be used in future impact evaluations. In order to achieve this, closer cooperation between INIA and MGAP is recommended, particularly between ministry offices that handle data and other non government public institutions like INAC, INASE, INALE. It would also be helpful if INIA organized its information about research, development and innovation by sector or production chain in order to facilitate impact evaluations in agricultural subsectors."[20]

There is also a need for agronomic research in:

- natural pastures, including an updated characterization of production in regional pastures;
- improved fields;
- animal genetics;
- cost/benefit of compulsory traceability;
- cost/benefit of various applications of irrigation (soil, crops, etc.), and
- quantification of strategic supplementation impact[21].

Also, in a recent study about "green economy", the authors suggest[22]:

"there is a need for an annual indicator in the agricultural sector that can measure the impact of soil erosion as a result of agricultural activity and can be easily accessed by the public. This indicator

[18]Paolino, C.; Pittaluga, L.; Mondelli, M. 2014. *Cambios en la dinámica agropecuaria y agroindustrial del Uruguay y las políticas públicas*. CEPAL. Series "Estudios y Perspectivas". No. 15. Montevideo, Uruguay.
[19]Carriquiry, M.; Gaudioso, R.; Mordecki, G. *et al*. 2015. *Hacia una economía verde en Uruguay: Condiciones favorables y oportunidades.* Economía Verde.
[20]INIA; IICA. 2011. *Evaluación de los impactos económicos,sociales, ambientales e institucionales de 20 años de inversión en investigación e innovación agropecuaria por parte del Instituto Nacional de Investigación Agropecuaria*. Uruguay.
[21]See Bervejillo, J. 2013. *"Variabilidad regional de la productividad ganadera" en Anuario OPYPA 2013. Uruguay.*
[22]

would be extremely useful when analysing the evolution of the state of a natural resource key to the country and to evaluate the impact of the enforcement of the law of responsible soil management and usage."

In general, the results of these studies need to be easier to understand, more replicable, better proven and with more economic analysis. Again, the way in which these studies are presented and disseminated is as important as the technical studies themselves.

Improvements in public policies

Although some public policy improvements are highly complex and exceed the scope of this study, the more "manageable" solutions can be divided into specific suggestions and those aimed at improving the business environment in general.

Specific suggestions include:

- improving the public-private participation (PPP) tool for developments like irrigation;
- supporting live cattle exports, thus sending positive signs to the market;
- improving road infrastructure (in the words of an expert interviewed, "*a well maintained road is more important than wheat fertilization*");
- better understanding production linkages — the analysis of primary productivity alone is not enough;
- improving transparency in the meat chain and price setting in general, although recent efforts in this matters are appreciated, and
- simplifying traceability and better communicating its macroeconomic benefits to producers (at a national level), so that they see it as a benefit rather than as a burden and an expense (even if the benefit is not immediate in dollars).

With regard to improvements in the business environment, the aim is to reduce risk in order to drive investment (including in technology) for an increased profitability — previously highlighted as an important barrier — and, therefore, improve productivity through:

- commercial openness leading to reduced duties for agricultural products, especially meat, in foreign markets;
- making sure that taxes on agricultural activity generate the desired signals and are predictable and fair, and
- reducing the "country cost" ("costo país").

Improvements in public policy are basically not intended to benefit the sector but rather to avoid creating obstacles. What is repeatedly mentioned is the need to stabilize the country and, therefore, the sector, so that a long term vision may be applied and the risk of innovation may be reduced.

As explained by an interviewee:

> *"It's not a matter of creating large public sector structures but of creating the macroeconomic conditions required to innovate and increase productivity."*

Financial improvements

The development of more and better insurance for the sector — like weather insurance, price insurance and others — was also suggested. The relevance of the occupational disease insurance implemented by the MGAP was underlined. It is also worth highlighting the pilot plan examined by Methol M. and Mila F. on the implementation of a pilot test of the livestock breeding insurance for droughts based on the NDVI index — *Implementación de una prueba piloto del seguro de sequía para ganadería de cría basado en el índice NDVI* —, published in the 2015 OPYPA annual directory.

Institutional improvements

This report does not intend to assess specific institutions.

As previously mentioned, we consider that in order to adjust expectations, transparency in the communication of the sector's public institutions objectives and scope must be improved[23].

Evidence suggests the need for improving the sector's institutions and teamwork. The sector requires more inter-institutional work and, despite some very commendable concrete efforts, there is a general lack of openness and coordination.

However, it is even more important to improve communication between the institutions and the sector itself. Action alone is not enough: communication must be improved. Time and again, while cross referencing information from interviewees, it became clear that many excellent inter-institutional initiatives were not known.

This need for institutional improvement is not new:

"The development of human resources, the ability to work in an interdisciplinary and inter-institutional manner, and new approaches to dissemination and training are crucial requirements for innovation in new technologies and their effective large scale impact in agriculture. […] Training and knowledge development through a network of universities, technological institutes and extension systems are key to achieving this goal. The focus should be on strengthening human resources specialized in new technologies, as well as promoting institutional articulation and integration, in the understanding that in these new times there will be no innovation without inter-disciplinary or inter-institutional work. In short, it would be relevant and necessary to promote the concepts and tools of precision agriculture through a pilot extension program."[24]

In a recent CEPAL[25] study, the following was already suggested:

"Capacity development around 'extended' agricultural institutions (MGAP, non-State public entities, such as INIA, INAC, IPA, the private sector and other legal entities). The focus is to converge on major strategic work orientations"

We should also highlight the project for improving competitiveness in the Uruguayan livestock sector through the development of new genomic tools for improved food efficiency and carcass

[23]Recommended literature about the economic impact of these institutions: INIA; IICA. 2011. *Evaluación de los impactos económicos,sociales, ambientales e institucionales de 20 años de inversión en investigación e innovación agropecuaria por parte del Instituto Nacional de Investigación Agropecuaria*. Uruguay.

[24]Chartuny, E; Magdalena, C. Ed ."*Manual de Agricultura de Precisión*". 2014. *Programa Cooperativo para el Desarrollo Tecnológico Agroalimentario y Agroindustrial del Cono Sur*.

[25]Paolino, C.; Pittaluga, L.; Mondelli, M. 2014. *Cambios en la dinámica agropecuaria y agroindustrial del Uruguay y las políticas públicas*. CEPAL. Series "Estudios y Perspectivas". No. 15. Montevideo, Uruguay.

quality of the Hereford breed — "*Mejora de la competitividad de la ganadería uruguaya por el desarrollo de nuevas herramientas genómicas que mejoren la eficiencia de alimentación y la calidad de canal de la raza Hereford*" —, analysed in the OPYPA 2014 annual directory by De los Santos *et al*.

Within this inter-institutional context, it is worth noting INNOVAGRO Fund and the significance of its independent monitoring and evaluation.

What will be the impact of the new situation in Argentina?

One of the secondary objectives of this research was to understand whether the new situation in Argentina — with a government more favourable to agriculture, new businesses and exports since President Mauricio Macri took office — could have an impact on the technological development of the Uruguayan agricultural sector.

This concern was based on the observation that a large number of technological innovations in this sector, particularly in agriculture itself, over the last 10 years, were driven by Argentinean producers and entrepreneurs. On the other hand, Argentina has begun to open up to the world and could be an important competitor for Uruguay in the subsectors considered herein.

The interviewees were asked two questions regarding the new situation in Argentina and its impact on Uruguayan agriculture:

- firstly, whether this can be detrimental to Uruguay since the country benefited considerably from the technological contribution of Argentinean entrepreneurs and producers in the agricultural sector, and
- secondly, whether Argentina's return to international agricultural markets could pose a threat to Uruguay as a country.

These questions were complemented by the literature reviewed on the subject, which is still very limited given these are all recent developments.

It is worth noting that there was total agreement on the fact that many Argentinean producers and entrepreneurs had decided to start agricultural operations in Uruguay in view of the situation in their country during Néstor Kirchner's and Cristina Fernández' governments. With them, they brought valuable technology and know-how. This impact was stronger in agriculture, a little less strong in dairy, and very low in livestock. The most relevant side of this contribution was “the change of the productive paradigm.”

In the first place, it is worth mentioning — as done by interviewees — the impact that Argentina may have because:

- it is clear that “there has been no flight of producers to Argentina,”
- not all Argentinean entrepreneurs and producers have returned to their country (many prefer to stay in Uruguay or distribute operations between both countries, since they are attracted to Uruguay for its legal and macroeconomic stability and a matter of quality of life);
- not all those entrepreneurs and producers who left did so because of a change in government, some had already left years before when international commodities prices began to decline, and
- the Argentinean situation is still not ideal and Macri's government policies are still very recent for any results to be seen.

Something that did stand out as a change for the Uruguayan agricultural sector since the new government in Argentina took office is that better relations between both countries have improved logistics issues.

In terms of technology and innovation, conclusions were that:

- the most positive aspect of the Argentinean contribution, in addition to management, was demonstrating what the actual potential was and "showing that it was actually possible to produce more and better," particularly in agriculture;
- Uruguayan producers have already incorporated these technologies, which will not leave the country even if all Argentinean entrepreneurs and producers do;
- it must be admitted that Argentineans have invigorated the agricultural sector, although where the next revitalizing force will come from is still unknown, and
- there have always been foreigners in the Uruguayan agricultural sector and there are investment funds from many nationalities, particularly in agriculture.

With regards to international markets:

- it is recognized that Argentina's international potential is enormous and that its country brand is very strong in international markets, especially in meat;
- it is understood that changes will be slow and the situation of the Argentinean agricultural sector will not change dramatically with a change in government;
- it will take Argentinean cattle stock a long time to recover, the country will not have the volume necessary to quickly step into all the international markets; it was also mentioned that the meat chain in the country "has been dismantled;"
- many interviewees consider that Argentina has a very large domestic market to supply, which generates less stimulus for exports as compared to Uruguay, which has such a small domestic market (in other words, Argentina has a long way to go in its domestic market before going out into world markets);
- it is worth mentioning that Uruguay, in the years when Argentina was almost isolated from international markets, made a great effort to position itself internationally and to set itself apart; additionally all the efforts by the entire productive chain and the government turned Uruguay into a strong competitor in relevant niches;
- practically all interviewees mentioned they are a lot more concerned about Brazil or Paraguay as competitors, whether for macroeconomic reasons (Brazil) or the low costs and production standards (Paraguay), and
- the prospect of working together with Argentina in several aspects including logistics, particularly in connection with China, was discussed.

The challenge we have as a country in this context is to maintain innovative dynamics, offer quality ("which is nothing other than knowledge") and constantly rethink competitiveness and differentiation, always opening new external markets and anticipating demand. There were some who understood that, especially as to Paraguay as a competitor, it is important to highlight what makes our producers better — in particular regarding meat— for international consumers, mentioning traceability but also the social footprint.

As stated before, all the above information is anecdotal and not statistically relevant; it is derived only from the 35 interviews conducted. There is clearly a lack of scientific research on the subject.

General conclusions

According to the evidence gathered, the barriers that prevent the growth of productivity in the Uruguayan agricultural sector for producers who are producing below their productive potential:

- rarely relate to a lack of supply of product technologies (inputs);

- are often related to a lack of process technologies, particularly in management

- are often related to a lack of macro- and micro-economic incentives and of a favourable environment for investment in agri-tech, and

- are likely to be related to weaknesses in extension and/or dissemination of technology.

It is important to stress that in the case of producers in any subsector who are working close to their productive potential, the role of agri-tech is absolutely crucial to maintain a position at the forefront and continue to drive innovation for all other producers.

Based on the evidence from this study, we believe that the path to increasing productivity through agro-technology:

- must focus on process technologies;
- must focus on dissemination, extension and adoption processes;
- requires more and better inter-institutional work;
- would benefit from the use of technology in the mitigation of the negative impact of climate variability, by stabilizing production systems;
- must rely on sound economic studies in order to design and evaluate programmes and projects, and
- must not overlook the introduction of cutting edge technologies for the most advanced producers, who lead sector innovation.

Suggestions proposed:

- should take into account entire systems and fragile balances, and
- should come from various disciplines and institutions, that is, from teamwork.

We believe that, in addition to improvements in productivity, agri-tech is critical because it facilitates:

- retaining and attracting young people and women to the countryside;
- improving farmers' quality of life;
- increasing the return on investment in other factors, and
- providing time to "do the thinking," keeping in mind that knowledge and differentiation are key for a country that cannot compete globally in volume.

This study agrees with the view of one of the interviewees who stated that "*a microeconomic revolution is required*" to improve productivity in the agricultural sector. We hope the present study will help emphasize this need for the good of the sector and of the country in general.

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Common acronyms and sites of interest

INIA National Agricultural Research Institute	**www.inia.uy**
MGAP Ministry of Livestock, Agriculture and Fisheries	**www.mgap.gub.uy**
INALE National Dairy Institute	**www.inale.org**
FUCREA Uruguayan Federation of CREA groups	**www.fucrea.org**
ARU Uruguayan Rural Association	**www.aru.com.uy**
FAGRO Agronomy Faculty, University of the Republic	**www.fagro.edu.uy**
Blasina y Asociados	**www.blasinayasociados.com**
IPA Agricultural Plan Institute	**www.planagro.com.uy**
UPIC Intensive Meat Production Unit	**www.upic.com.uy**
INAC National Meat Institute	**www.inac.gub.uy/**
SNIG National Livestock Information System	**www.snig.gub.uy**
INC National Colonisation Institute	**www.colonizacion.com.uy**
Rural Federation	**www.fr.org.uy**
National Committee for Rural Promotion	**www.cnfr.org.uy**
Conexión Ganadera	**www.conexionganadera.com**
ANPL National Association of Dairy Producers	**www.anpl.org.uy**
CONAPROLE National Cooperative of Dairy Producers	**www.conaprole.com.uy**
OPYPA Agricultural Planning and Policy Office	**www.mgap.gub.uy/unidad-ejecutora/oficina-de-programacion-y-politicas-agropecuarias**
Consultora Apeo	**www.apeo.com.uy**
DGSG National Board of Livestock Services	**www.mgap.gub.uy/unidad-ejecutora/direccion-general-de-servicios-ganaderos**
Genética Chebataroff	**www.chebataroff.com/**
ANII. Research and Innovation National Board	**www.anii.org.uy**