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The relationship between innovation and inequality

The case of Brazil in the last decade

by

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This work aims to explore the relationship between innovation and inequality, specifically in Brazil in the last decade. Innovation in one hand is an unquestioned driver of growth, while inequality in the other is a major economic problem, one that arguably hinders growth. Using literature review and three types of analysis, (1) the global innovation index together with the world bank gini index, (2) questions and answers from the World Value Survey and (3) another survey designed to this work, we were able to identify a negative relationship between them, what goes according to the previous intuition: low levels of inequality come together with high innovativeness; high inequality is connected with low innovation levels. Furthermore, this work is along the lines of the literature, as it shows that this relationship has other economic variables, i. e. education, employment, and knowledge building. National innovation systems should then address policies such as inclusive innovation in order to really develop, especially in the countries of the South – the case of Brazil.

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1 Introduction

Innovation is an unquestioned source of economic growth and development. Inequality, in the other hand, is one of the most debated issues in economics in the present day. At the same time, the world sees unprecedented technological advancements and an increase in inequality to probably unseen levels in history. We face at this very moment automation replacing jobs, and an expectation that this process will continue for long. In fact, a whole set of economic, social and even psychological problems have scientific connections to inequality (Wilkinson & Pickett, 2009).

Some scholars otherwise still argue that inequality has positive effects in growth (e. g. Tselios, 2011), and innovation effects have been empirically perceived as having both positive and negative effects in different countries. If we could improve our understanding of those two important variables in the complexity of economics and understand how they interact, we could tackle the problems more effectively, achieving more equality while innovating.

The innovation literature can be said to not address inequality properly yet, and also to have bias towards the developed world, leaving the developing nations with an unfitting innovation theory. In that perspective, Cozzens & Kaplinsky (*in* Fagerberg, 2009, ch. 3) point out linkages among (1a) competence-building, (1b) process, product and service innovations, and (1c) functional and chain innovation, in one hand; with (2a) household income inequality, (2c) inequalities by place (continents, countries, regions) and in (2d) power relations on the other. Their work remarks links between innovations and inequality, although without addressing some questions. How does income inequality influences the levels of innovation that a country achieves? How does it affect the National Innovation System (NIS)? Especially, how does innovations affect inequality levels?

Importantly, it is necessary to clarify what concepts are adopted in the present work. We look at inequality mainly within the perspective of economic inequality, not completely discarding wealth inequality, but mostly *income inequality*. The main reason to do so is that income inequality is widely measured and used in practically all studies reviewed in

the literature (second chapter), although similar study with opportunity inequality could even may be more representative, but a lot harder to measure. On the other side, the concept of innovation varies considerably more. In general, this work addresses innovation as a *novelty with economic use*. As this concept is sometimes addressed in either broader or narrow ways, it is treated with this simple concept, unless mentioned otherwise. Yet, NIS is a broad concept, and varies from author to author. Among the definitions, we use what we think is the most appropriate to this work, encompassing not only the developed world but also the developing south: “NIS is an open, evolving and complex system that encompasses relationships within and between organizations, institutions and socio-economic structures which determine the rate and direction of innovation and competence-building emanating from processes of science-based and experience-based learning” (Lundvall *et al*, 2009, p. 6). Within this definition, it is possible to realize that this relationship is just one part of a bigger and complex net of structures, institutions and actors. That does not invalidate this work, but shows the limitations of it.

Ultimately, this work aims to explore how is the relationship between inequality and innovation, especially in Brazil. In a qualitative approach, the analysis is developed with three different sets of data. First, it uses the Global Innovation Index (GII) as a measure of innovation, and the World Bank Gini index (WBGI) as an inequality measurement for a more general analysis. Secondly, it uses answers from the World Value Surveys (WVS), choosing the ones that had Brazil among the researched countries, as well as the questions that could be interpreted as closely related to either innovation and or inequality. Lastly, it uses a questionnaire developed by the author for this study, for the specific case of Brazil, composed by alternative questions and one open-ended last comment.

Brazil’s case is an interesting one regarding this study, because of some national uniqueness. The country has high levels of inequality, even though showing a recent downward trend from earlier than 2007, with a deceleration on inequality reduction in the last years. Brazil positions itself yet in an intermediate zone in innovation indexes (GII), so there is significant space for improvements in both perspectives. In sum, Brazil has a lot of room for development, and we believe that this path can not disregard both subjects and their relationship.

The main theory states that the more unequal a country is, the less innovative. At the other hand, innovation is believed to generate inequality at first, through 2 main paths:

skill biased technological change (SBTC) and temporary monopoly of recently researched and developed products. Yet, innovative processes can lead to gains in productivity and consequently in wages; social innovations may influence downwards changes in inequality, and inclusive innovation is a mandatory policy for the case of Brazil.

Social innovations is a concept that connects not only inequality and innovation but at least partially their relationship. It is a somewhat new concept, that could be defined as “new ideas that work to meet pressing unmet needs and improve people’s lives” (Mulgan *et al*, 2007). We could see social innovation as new policies, but also as new ideas, as the concept presents, from the private sector. Inclusive innovation, however, is a even more recent concept, that not only connects, but brings closely together innovation and inequality. Its core concept essentially deals with “the structures and processes required to develop and deliver innovative technologies for poor consumers (Foster & Heeks, 2013). As described, it relates more to poverty than inequality, but those are two sometimes hard concepts to separate. This work then adopts this as an underline view when looking at this relationship.

Lastly, this work intends to probe the relation between inequality and innovation, but aware that further studies are necessary to fully apprehend this relationship, in time and in space. Yet, this work entitle itself to draw some conclusion about the case of Brazil during the last decade.

Despite of the complexity of this relationship heavily mediated by growth, but also affected and affecting employment, education, knowledge-building and consumption, among others economic variables that could influence and be influenced by both inequality and innovation, and the relationship between them, we can say, after the literature review and the three analysis that the relationship is negative; while we see high levels of inequality, we see low levels of innovation and vice-versa. Finally, we indicate, regarding policy implications, that institutions and policies such as inclusive innovation could both reduce inequality and spur innovations.

1.1 Research Problem

Innovation is acknowledged by mainstream literature as one essential driver to economic growth, in both developed and developing countries. Inequality, in the other hand, is definitely one of the most debated issues in economics in the present day. Dealing with inequality in a broad sense, one should consider how innovations occur and what are their effects on income, wealth, opportunities and so on.

The innovation literature grew substantially over the last years, as innovation has been proved both theoretically and empirically to be a main contributor to growth and development. Yet, scientific articles and books at first addressed the issues through a northern perspective, leaving the south with a somewhat unfitting theory, as innovation did not occur in the same way in the developing world as it did or does in the rich countries. Realizing this gap, scholars then started to approach the subject from a south perspective, adapting the north theories to the south nations.

It is important to highlight the most important definitions used in this work, as the concepts may vary significantly in time and among authors. Innovation bring more attention as more disciplines acknowledge its importance, broadening its concept and definition. This work mainly treats innovation with a simple and broad definition: a *novelty with an economic utility*. It is obviously a much more complex and wide concept than that. The GII, with their pillars, inputs and outputs, and its changes among these year are a good example of the evolving and complex concept it is. Even so, through this simples definition, we look at products, but also to services and processes innovations. Inequality, at the other hand, is a more intuitive concept. We look in this work mostly through the perspective of income inequality, embracing all kinds of income, as interest, rents, profit participations, but, mostly, wages. So, wage inequality is the fundamental approach this work entitles. Furthermore, it aims to explore the relationship between these two important macroeconomic matters. In that perspective, some works have been developed in order to understand the relationship between inequality and innovation.

But there are important question regarding which are the best ways to measure innovation and NIS, as well as inequality. The majority of the revised works here use proxies

as patents in order to measure innovation. The difficulties at measuring innovations are high. Quantitative comparison are often unattainable, as there are qualitative differences that are sometimes hard to scale; yet, an innovation by definition is something new, it is also often, involving knowledge building and learning capabilities, making “technical measure comparisons only rarely meaningful” (Smith, *in* Fagerberg *et al*, 2005). Logically, NIS are even harder to evaluate. Because a NIS involves a numerous set of inputs, such as education levels, enterprises’ R&D investments, etc.; processes and the outputs – the proper innovations –, it is clear that scaling such a complex IS is not easy. Meanwhile, it is not to say that scholars can not attempt to do so. For that matter, the GII is an example of a bold (and successful) try. Hitherto, scholars have just been able to classify NIS’s (Chaminade & Padilla-Pérez, 2017), and other works have done similar processes. These are the best measures we have so far. Nothing that impedes the future reserve us even better measurements.

Inequality, on the other hand, can be quantified in some different ways. We can use quantification such as the 20:20 ratio (the division of the income of the 20% richer over the 20% poorer), quartiles, deciles, and so forth. We chose to use the WBGI because of its availability, its easiness to understand and use, and yet because it is one condensed measure, making it easier to relate to other variable. Piketty controversial arguments are, in fact, undenied by the WBGI. Inequality has been declining worldwide as the WBGI indicates, but top income shares has been growing in a large number of nations (Aghion, 2002; Atkinson, Piketty & Saez, 2010).

Yet, because of the difficulties in measuring innovation and NIS, we use other 2 sources of data: the World Value Survey (WVS) and one questionnaire designed to this study. With the three sources, we think that we could better explore the relationship between both issues, making the evidences and conclusions more solid.

1.2 Outline of the Thesis

At this introduction, we aimed to show what is the main goal of this research – exploring the relationship between inequality and innovation, especially in Brazil in the last decade, how it is planned to fulfil that – through three types of analysis, and what are the main findings and limitations –, further research is necessary to fully understand this relationship and to further develop the theory, but we could find indication that inequality hinders innovation, as our intuition predicted; also, our three sources combined with the literature review allow to indicate that the relationship is endogenous – one affects the other in different ways.

The next section presents the literature review and what has been done so far in order to better understand this relation. The third section regards the three sets of data, how was it obtained, treated, interpreted, its advantages and limitations.

The fourth section regards the method used. It entitles how exactly we used the first set of data: crossing GII with WBGI in order to understand the relationship; how we selected and interpreted the WVS questions about Brazil, and finally how was the survey for Brazilians regarding both issues designed and responded. The actual analysis comes in the fifth section, where we interpret the results. The sixth and final section is where we draw some conclusions and mention where some of the possible future research could point to.

2 Theory and previous research

The literature approach on the relationship between inequality and innovation is not the broadest, but there are some works that intended to deepen the understanding of this relationship. “The field is in a state of infancy” yet (George *et al*, 2012). Nevertheless, they could be divided in (1) works that have explored the causation that **innovation has on inequality**, and (2) the effects that **inequality has on innovations**. In both cases, there are works leading to ambiguous conclusions. Some of them concluded that (1a) innovations have positive effects in reducing inequality, (1b) others, that innovations lead to an increase in inequality; in the opposite line, there are works arguing both that (2a) inequality affects innovation in a positive way, enhancing it, and (2b) that it brings negative effects on innovation, not setting the right environment to spur it. This section is going to explore in more detail such literature. Furthermore, we bring some interesting concepts that can and should be addressed when one is analysing the relation between inequality and innovation, as social and inclusive innovations. Lastly, this work positions itself among that literature.

When looking at the relationship between inequality and innovation, it is impossible to exclude growth and development from the equation. Moreover, growth and development are often treated as equal concepts, but there is an important difference, as development is a more broad and complete concept, of which growth is a part. More often than not, economic growth is given as the only driver of development, but that is not always the truth, as we are able to see when studying this relationship. Yet inclusive growth is perhaps the most appropriate concept when discussing inequality. While innovating, an unequal nation should always be aware of the possible negative outcomes of that novelty, i. e. the lost of jobs. Where would that share of work force be relocated and what training is necessary are just examples of what inclusive policies should address when innovation diffuses.

Furthermore, inequality and innovation are mediated not only by growth and development, but also by institutions. How they shape institutions and are shaped by them, how is the role of institutions in each region, country, city in the correspondent innovation system definitely influence heavily how the relationship varies in time and space.

We start with a review of the more specific literature – the ones that have already researched both subjects and their relation – with the ones that look at this relation through a perspective that see causation *from innovation to inequality*. Works that look at innovations through a Schumpeterian view see that process innovations increases inequality through skill biased technological change (SBTC). As new products and processes emerge, skilled workers tend to benefit from the scarcity of well-prepared work force. The demand of these skilled workers rise, and as long as the rent of novelties allows the hiring firms to see an upward in revenue their wages grow in a higher pace than the non-skilled work force. These arguments are the most important ones in Aghion's (2002, 2015) works.

Yet, besides through SBTC, innovations would increase inequality through general purpose technologies (GPT), namely in the diffusion phase. While new blocks of processes and products spread geographically, inequality would increase as the demand of skilled workers grows in a faster pace than the supply of those employees (Aghion, 2002). Later on, the same author came to the empirical conclusion that countries with different levels of innovation presented through history uncorrespondent degrees of inequality. To him, the more innovative, the more unequal a country becomes. (Aghion *et al*, 2015).

In the same line, Angelone *et al* (2009) have come to conclude that the greater skill intensiveness is an innovation, the greater inequality is achieved *a posteriori*. Looking at innovations and wage polarization in Europe, in a neo-schumpeterian view, they found evidence that wages had scattered in Europe since the 1990's. Inequality had risen less, however, in countries that had stronger labour regulations and unions.

When measuring inequality in relation to the share of top income (e. g. 1% of the top income distribution), other work also finds that more innovations lead to less inequality. In a recent study, also in a Schumpeterian view, it is argued that creative destruction lead to inequality being reduced. Through this view, SBTC could not be responsible for that. Instead, the entrepreneurs extra efforts in (re)search for new ideas in order to replace current business lead, in comparison to the efforts of the current business to maintain profits of the present products and services, in the long term to a Pareto distribution (Jones & Kim, 2017). That conclusion have the assumption that income distribution follows a power law, and interestingly concludes that inequality is fractal in nature, after all.

Nonetheless, the same work, as others, found evidences on the opposite effect. Innovations could reduce inequality, if innovations in products and processes were accompanied by also innovative policies and practices. When considering the effects on novelty in society, one could anticipate how it would affect wages, for example, through SBTC, and deal with it in advance. In a different philosophical view, Cozzens' (2008) paper also saw that innovations combined with different policies and practices could lead to reduction in inequality. Through that perspective, the Kuznets curve does not explain reality. Instead, when novelties overcome previous products, services or processes, there is always an increase in inequality, and that does not change by itself, but only with policies. Therefore, this should be addressed in order to reduce inequality and stop it from reproducing itself – stop the vicious cycle.

In the opposite direction, there are some works that tackle the relationship with causation in the other way around. Inequality is said to affect innovation through setting the right environment that could spur innovative actions of small entrepreneurs, and research and development (R&D) investments. Building human capital, knowledge links and good infrastructure requires an environment of less inequality.

Again, it is not possible to ignore that there is a closely related connection between the endogenous technical change that derives from innovations and the wage structure dynamics (Aghion, 2002). Despite of existing conditions that are local (i. e., employment), this complex interaction net expands beyond national borders.

Schumpeter did not see an important role of inequality in the emergence of innovations and consequently in growth, as he assumed homothetic preferences; this view assumes then that demand does not depend on inequality. Such vision is outdated by behaviour economics, as ones considers that preferences change and people do not always behave rationally. In fact, innovations are more often than not expensive (here we relate to new technologies that required R&D investments, passed on later to the price), so less inequality would certainly lead to a better market. Yet, inequality does change the time path of demand, as the greater inequality a market has, greater the time that the entrepreneur would only sell his new products for a smaller share of the population, augmenting the recovery time of the initial investment. The more concentrated a market is, the lesser efficient would the methods of production be. The rich direct naturally more income to innovative (expensive) products, as the poor direct a greater share to basic needs (cheap). The less poor people buy

just-released products, the less efficient is this market and thus less growth generated (Zweimüller, 1999).

Departing from this assumptions, Zweimüller (1999) imagined three scenarios: the first, where only the rich buy innovative products; a second, where rich and poor are able to buy such products; and a third, where no one buys the novelties initially. His analysis concluded that on the first scenario, inequality would harm growth, as the innovator has less profit for only selling to rich. In the second one, growth would be independent of inequality, and still incentives to innovate remain. In the third, inequality would be beneficial to growth, as innovators would prefer to sell less at that moment and more (to rich and poor) in the future.

Even though being minor, there still is literature claiming inequality as beneficial to growth (e. g. Banerjee & Duflo, 2000). That is not the view of this work. We could agree that some level of inequality may be necessary to spur innovative action, giving incentives to entrepreneurs. The key problem with this theory is that the vast majority of recent works have showed that inequality hinders growth. And growth can be closely connected with innovation, when the last causes the first.

The majority of literature regarding innovation and inequality considers that the latter has an overall negative effect on the first. Works approaching the subject through a systemic view, i. e. national and regional innovation systems (NIS, RIS) see that inequality naturally hinders innovations. To overcome that problem, these works recommend egalitarian, pro-poor and fair policies (Cozzens, 2008). These policies would aim to reduce vertical inequality (income and wealth), to improve the conditions of the bottom end of income distribution and to reduce horizontal inequalities (gender, ethnic, religion-related), respectively.

Another work that brings similar conclusions is Arocena & Sutz (2003). From a South perspective, they argue that “proactive equality” is a mandatory task for Innovation Systems in the developing world. Innovative products and processes always lead, according to the authors, to destabilization and change. If not accompanied with policies, it would lead to more inequality. Yet, they argue that each country or region require a unique IS, encompassing formal learning but also learn by doing. If those items were in a more equal

context, it would increase capabilities of adapting, upgrading productivity and, at the end, more innovation.

Yet on the effects of inequality on innovations, Tselios (2011) concluded that the relationship between these two important aspects is dynamic, and it may be cyclical. In general, he concludes that small increases in inequality favours innovation. He argues that innovations and inequality are major setters of economic organization, although the relation between them should be looked into regionally, as the knowledge spillovers occur within the region. The main conclusion of this work is that price effects are as greater as market size effects as more unequal a country is. Similar argument is brought by Hatipoglu (2012). In a quantitative approach, and assuming technological progress as the “main engine of growth” (Sedgley, *in* Hatipoglu, 2012), he was able to find a non-linear relation between inequality and innovation. Even though this work does not affirm the shape of the curve, it finds evidence that it is not a “U” curve. His conclusions lead to finding the relationship dynamic, endogenous and non-linear. The weakness of this work is perhaps the assumption of treating product and process innovations as the same.

In an institutional perspective, the work of Weinhold and Nair-Reichert (2008) say, in sum, that a strong middle class and the right institutions, especially intellectual property rights would altogether lead to spurs in innovations.

Recently, another important work have checked this relationship. They argue that “income and wealth inequality has a negative impact on trust between individuals and organizations” (Chaminade & Padilla-Pérez, 2017). Trust *per se* does not equal innovation, but it is one essential part of an innovative environment, and therefore essential part of its inputs.

Furthermore, the brazilian literature about both subjects isolated is significant. However, no work we are aware of faces this relationship, at least while considering income inequality. A few works address regional inequalities and knowledge building (i.e. Cavalcante, 2011), and other looks also into regional inequalities, but as a cause and consequence of science, technology and innovation (Brito Cruz, 2010), demonstrating path-dependency.

In sum, the theory about the connection between innovation and inequality is not yet conclusive. Most works, however, point that the relationship is negative, which would be the intuition. About causation, the literature investigated it from one to the other, and from

other to the first. The authors point some results, but they do not form a theory just yet. This work aims then to add a small contribution towards a future theory about this relation, if we ever could unify one.

2.1 Theoretical Approach

The theoretical approach of this work is mostly based on the NIS theory regarding the developing world, but do not exclude completely the previous researches and ideas. It is perhaps a matter of adjusting the already well developed theory of NIS to the South, being aware that inequality is a major influence in NIS's, especially in the developing world. It actually is one of the reasons of NIS being considered fragmented. In that classification, we put countries that have “pockets of innovations” (Chaminade & Padilla-Pérez, 2017), with high-tech companies at the side of a good university, but both surrounded by “favelas” in a clear and typical example.

A perhaps essential theory to understand inequality is the Kuznets' theory. It argues that inequality tends to rise while a country develops, something known as the Kuznets curve (1955). Reviews of his work showed the relevance of the theory, although pointing out important exceptions (Acemoglu & Robinson, 2002), i. e., Latin America. Importantly, some possible causes of the inverted “U” shaped curve of inequality through time are also pointed, as the transition from agricultural to industrial society (so, a consequence of innovation), as argued by Kuznets himself.

The most compatible to this work are the views of Williansom (1985) and Atkinson, Piketty & Saez (2010). Williansom argued that technological change increased wages faster than the return of capital, while Piketty (2014) said almost the opposite: the return of capital being higher than economic growth always leads to increasing inequality. Interestingly, both arguments could be interpreted as innovations would reduce inequality. Williansom's idea is that wages rise more (perhaps by SBTC) rapidly, reducing income inequality, while Piketty (2014) showed that in history, the path of increasing inequality was only interrupted a few times, with technological changes being the most important ones (also perhaps by SBTC).

Furthermore, inequality is well connected to several social and economical problems by scholars. Homicide rates, racism, smoking, suicide rates, status of women and level of trust are only examples of issues that are more correlated to inequality levels than to per-capita income (Wilkinson & Pickett, 2009). Inequality is faced at this work as a serious

and probable worst economic problem there is. The consequences of inequality high levels are demonstrated over the years and in different places.

Yet, it is impossible to ignore that both subjects are also connected to institutions. The new institutional economics (NIE) have developed several works about innovation and how the western institutions are connected to good levels of innovations. At the same time, several other works relate wrong institutions with inequality. Within both subjects, scholars see that history matters and path-dependency is a major factor. This is not the focus of this work, but at the same time, such explanations can not be ignored.

Subsequently, investigating the connection between inequality and innovation, and understanding it, we could maybe tackle more efficiently and effectively these economic issues and accelerate the development of the south.

3 Data

In order to explore this relationship, this work uses three sets of data: first, it looks at the mentioned relationship crossing the Global Innovation Index (GII) as a measure of innovation, and the World Bank Gini Index (WBGI) as a measure of inequality. Secondly, it approaches the question through the World Value Survey (WVS), a survey developed in six waves in several countries. Finally, we analyse the relation between inequality and innovation through a questionnaire developed by the author for Brazil.

It is a fact that measuring innovation is not an easy task. It is arguably impossible to fully capture, but its main aspects, as inputs, processes and outputs do not preclude measurement. The most immediate problem is that innovations are new by definition and therefore lead to qualitative differences to previous generations of products, services and processes, making it harder to compare them quantitatively (Smith, *in Fagerberg et al*, 2005, p. 148-151). In another words, it can be hard to compare, for example, smartphones with the previous generations of cellphones. They are different generations of similar, but not equal, products.

Despite of the important limitations on measuring innovation, an index such as the GII shows a much more complete than the usual figure of what in fact is innovation in a systemic view. The quantitative works done so far more often than not only addresses proxies of innovation, such as number of patents. That is not only a problem of compressing a very complex and interconnected net of inputs, processes and outputs in an inefficient unique measure, but it is also not likely to fully represent innovation in the most simple definition: a novelty with economic use. A patent is just a legal registration of an invention, but that *per se* does not necessarily guarantees that it will have an economic use in the future.

3.1. **GII x WBGI**

Developed by INSEAD in collaboration with other organizations, the global innovation index was first figured in 2007, and had another seven reports since then. In a

comprehensive index, it is intended to capture innovation not just as proxies, but as the actual economic concept behind it. It has changed over time and evolved, as we address in more detail.

From the first year, it was calculated on a combined measure of inputs and outputs. The inputs were divided in five categories: institutions and policies, human capacity, infrastructure, technological sophistication and business markets and capital. The output was calculated in three aspects: knowledge, competitiveness and wealth. To get to each pillar index, it uses a combination of objective data from several sources, such as the World Bank, and some subjective data from the World Economic Forum's annual executive opinion survey.

The final picture of 2007 was captured on 107 countries, excluding some that had limited data. The eight pillars are then condensed in one index that goes from 1.00 to 7.00.

In 2008-09, the report maintained the measurement structure with eight pillars: five on the input side: institutions and policies, human capacity, general and ICT infrastructure, markets sophistication and business sophistication; and three on the output side: knowledge creation, competitiveness and wealth creation. Yet condensed in the final GII, ranging from 1.00 to 7.00.

In 2009-10, a slightly different approach started, with seven pillars divided in 5 enablers and 2 outputs. The first still counting institutions, human capacity, general and ICT infrastructure, market sophistication and business sophistication; the latter in scientific output, and creative output and well-being. In addition to that, it was also calculated the innovation efficiency, as the ratio from the outputs and the inputs or enablers.

The 2011 report remained in the same pattern, this time encompassing 125 countries. One important difference from this report on is that the scale changed from one to seven to a zero to one hundred scale.

The input is yet pillar is divided into 5 sub-pillars. The "institutions" sub-pillar is, according to the report, calculated as a simple average of three sub-measures: political environment, regulatory environment and business environment. The "human capital and research" pillar is divided into education, tertiary education and research and development (R&D) indicators. The "infrastructure" pillar is composed by ICT, energy and general

infrastructure indicators, while the “market sophistication” subindex is divided into credit, investment, and trade and competition. The last input index, business sophistication is composed by knowledge workers, innovation linkages and knowledge absorption.

The output subindex is again divided into two sub-measures, “scientific output”, subdivided in knowledge creation, impact, and diffusion; and “creative outputs”, composed by creative intangibles and creative goods and services indexes.

The 2012 report adopted a different concept of innovation: “An innovation is the implementation of a new or significantly improved product (good or service), a new process, a new marketing method, or a new organizational method in business practices, workplace organization, or external relations” (Global innovation index, 2012). However, in the same time, the general index had equivalent measurements then the previous report. The energy subindex was replaced by ecological sustainability, and an extra output subindex was added: online creativity.

In 2013, the main novelty in the ranking was the creation of an additional index: the efficiency ratio. Comparing how much innovation output there is in each nation to the correspondent input, they adopted an interesting approach, looking at the efficiency a country has on its inputs at creating more outputs. That is a closer measure to the systemic framework. Generally, it kept the former year’s measure concepts.

In 2014, as in the year before, the output index returned to encompass just two sub-measures: knowledge and technology outputs, and creative outputs. In general, however, it kept measuring the same variables with the same methods.

Finally, the same framework was yet used in 2015. In sum, we could see in this section, in a broad view how the GII was designed, how it was applied and how it changed over almost a decade with the aim of measuring innovation in different countries. It is certainly not an easy task, so some critics are possible. For example, even though it is not totally clear the exact method they use in a somewhat large sense a subjective view to a complex and hard to measure variable, but objectiveness is essential in science. Even so, this is the most comprehensive known innovation measure. It has yet evolved and became a lot closer to the correspondent theory framework.

On the other side, the gini index is the most used measure of income inequality. This index has its advantages and weaknesses. The main advantages of using the Gini index is its availability, and its relative easiness to understand and to interpret. Because it is characterized by a single number, it is easy to capture and compare income levels differences. The main disadvantage is that it does not show in which share of the income has the main contribution to the concentration. In that perspective, it is better to use deciles, quartiles and so on. There are others other measures of inequality, as the Palma ratio, the 20:20 ratio, coefficient of variation and others. For this study, as we aim to compare countries in general and then narrow down a little in Brazil in order to explore the relationship between inequality and innovation, the WBGI is perfectly enough.

The Gini index is then calculated as the integration difference of the Lorenz curve with the ideal distribution curve (straight 45° line). The closer to zero is the index, the closer of the ideal distribution it is. It is a static measure – on one point in time.

Furthermore, in this case, we use the World Bank Gini Index (WBGI) in order to analyse the relationship of inequality and innovation. The source is actually the UN-WIID (United Nations World Income Inequality database) that gathers several income inequality databases, the World Bank among those. As this one was the dataset with the most observations, this was the chosen index.

3.2 – WVS

For the second part of analysis, we use the World Values Survey dataset. It is developed by a network of scientists aiming to study changes in values, and their impact on life. The association of scientists is headquartered in Stockholm, and the first wave started in 1981. Since then, they managed representative national surveys in almost 100 countries in six waves. According to them, these data have been widely used by political scientists, sociologists, economists, government officials, journalists and students, all analysing links between cultural factors and economic development.

3.3 – Survey

Finally, we have designed a survey to ask people about their perception, in Brazil, of both subjects and the influence that one has in the other. The survey was made online, in Portuguese language, and was made available to Brazilians. It was a set of 11 closed-ended questions and one open question for people who wanted to give their opinion about the subject as well as about the instrument. It was made available for everyone that wanted to participate, and had 50 responses.

4 Methods

This work aims to explore the relationship between inequality and innovation. In a qualitative approach, it uses first two datasets, the GII and the WBGI, to get a general view of how is the relationship between inequality and innovation, drawing some initial general tendency. Secondly, we aim to analyse the same relation through some questions of the WVS in Brazil. At last, we use a survey through which we aim to analyze this relationship.

Regarding the first analysis, we made some adjustments to the GII. First, the index was calculated at first in an index varying from one to seven in the first three reports (2007, 2008-09, and 2009-10), and changed from that to a different scale (0-100) in the following reports, for the years 2011, 2012, 2013, 2014, 2015 and 2016. In this work, the years 2016 of GII is not used as we have no data for the year 2016 of the WBGI.

So the adjustment was at first transforming the scale of the first three reports from 1 to 7 to a 0 to 100. We did that using the following formula:

$$\text{Adjusted GII} = \left(\frac{\text{GII} - 1}{6} \right) * 100$$

Using the adjusted GII for the first years, we are able to compare them with the following years and use it to correlate GII with the WBGI. Using mostly descriptive statistics, we aim to identify some sort of pattern, and compare it with our intuition. This intuition is that both variables are negatively related: as one grows, the other tends to diminish.

In the second analysis, we aim to choose some questions related to innovation and to inequality from the WVS in Brazil. We are only able to capture, however, people's opinion on both of that matters.

Finally, after designing a survey (a copy of that is in the appendix) and receiving the response of 50 people, we also try to better understand how does this relationship is, and do that also looking at people's opinions. Indeed, it is a rich source, especially the final open-ended question.

5 Empirical Analysis

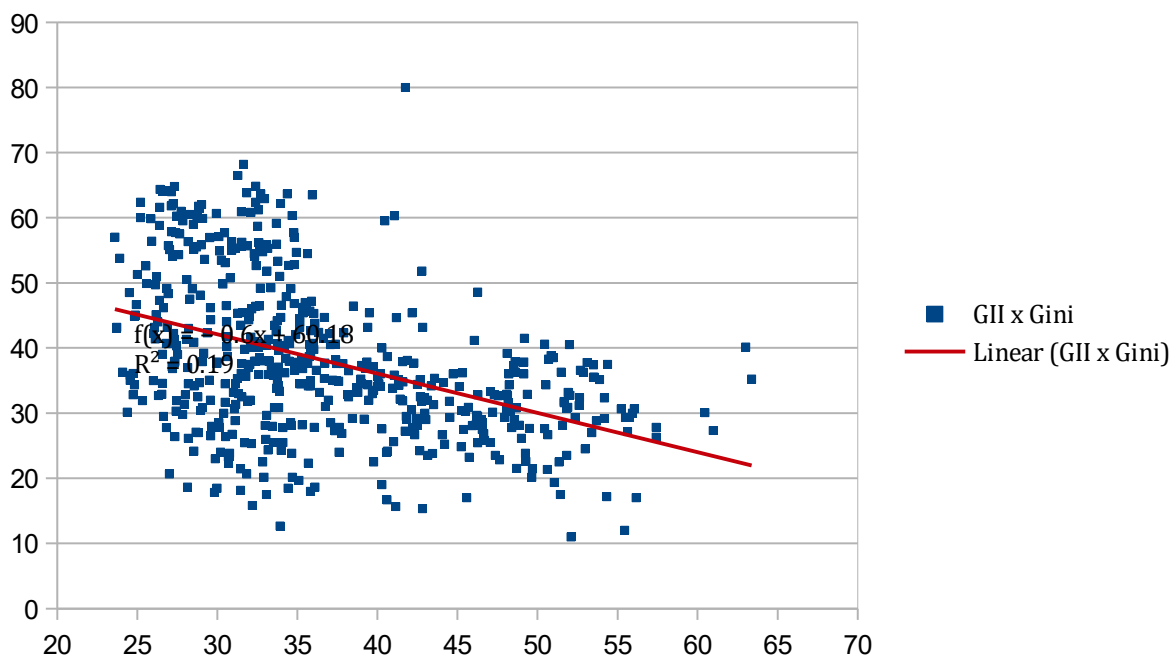
This chapter is divided into three sections. In the first, we look into the relationship between inequality and innovation using the GII and WBI relation. In the second section, we explore the same relationship with questions and answers taken of the WVS. Finally, we analyse the perception of people of the same relation in the Brazilian context. The next section draws then some conclusions.

5.1. GII and WBI

As mentioned, those are index numbers. The first is a national aggregate combination of objective and subjective measures. The last is a single measure of the inequality level, and is also aggregated. At combining both indexes, for all the years we have both, we came to a 540 observations of both measures, relating the same year and same country. The scatterplot can be seen in figure 1.

With the adjustment of the first three years indexes, we have plotted a scatter graph, adding a trend line, the trend linear equation and the R^2 , as we can see in figure 1.

Figure 1: excel graph and formula, self-made – correlation between GII x WBI



A further quantitative study could be further develop using both indexes, but we could infer something from that graph: we can see a negative relationship between them. The more innovative, the less unequal, and the more unequal, the less innovative a country is. That is according to our intuition, but more importantly is along the lines of most literature, agreeing that they have impact on each other. It finds evidence, however, to contradict Banerjee & Duflo (2000), if one agrees that innovation is at least one major source of growth; importantly, this also contradicts Tselios (2011), as growing inequality would not favor innovation, in general.

Beyond that, it is possible to notice that some points stand out, as the top one. That corresponds to the United States at 2007. In that year, the US was in the top of the GII, but we can see that their inequality level is not among the smallest.

The far right two points correspond to South Africa at 2008 and 2011, with WBI at almost 64, and correspondent GII at 40 and 35, respectively. It one of the most unequal countries in the world. Of the observation taken into account on this study, both measures correspond in fact to the higher inequality of the dataset. It is also possible to notice that the country interestingly does not show the lowest levels of innovation. Several countries demonstrate lower levels than South Africa. In most observations, the lowest levels of GII correspond to countries from Latin America, as Bolivia and Paraguay, and Sub-Saharan Africa, I. e. Cameroon and Mozambique.

The least unequal area of the graph is dominated by North and East European countries. Norway, Iceland, Finland, Slovakia, Slovenia and Ukraine represent the far left observations. Sweden, Norway, Finland, Iceland and Denmark show, however, much higher innovation indexes, and these points locate at the top left, above the trend line. Ukraine, Slovenia, Slovakia and Czech Republic observations are seen at the low-left region.

In sum, even when we consider the farthest points, it is somewhat clear that the relationship between those two macroeconomic variables is negatively correlated. In general, the higher the innovation level, the lowest the inequality; at the other way, the highest

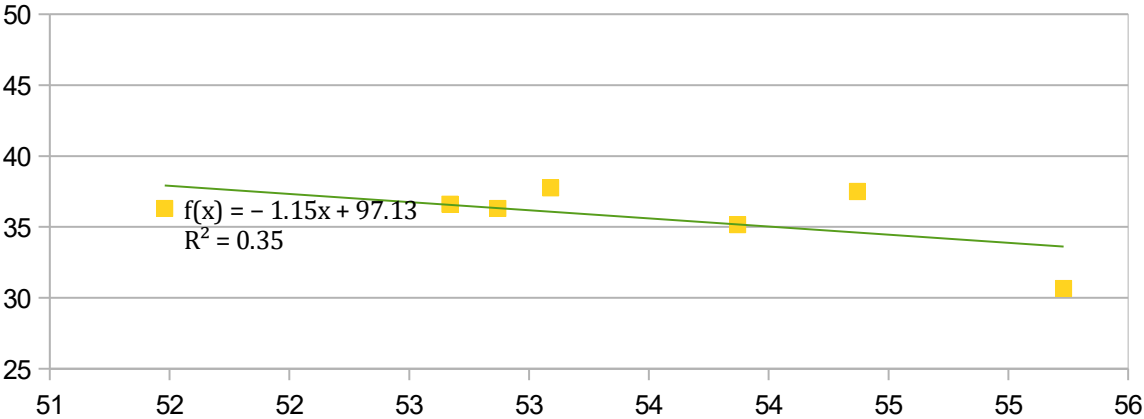
inequality shown, the lowest innovation is seen. In perspective, we find a significant relation; not in the statistical sense, but empirically. We can then see a clear trend that innovation is negatively correlated with inequality. The higher one is, the lowest the other tends to be, in general. There are, obviously, exceptions and points far from the curve, but that is the general trend.

That result, however, rise an interesting question at the policy level. In order to have a low inequality should a country then not spur innovation? Should it even create disincentives to innovation? The most obvious answer in the context of what drives economic growth and development is an obvious no. Yet, when a country designs economic policies in order to support and give incentives to innovation, it is necessary to develop awareness about the possible increase in inequality effects. Addressing the issues according to Cozzens & Kaplinsky (in Fagerberg, 2009) and Chaminade & Padilla-Pérez (2017), for example, would make possible to spur innovation and at the same time, at least, to maintain the same levels of inequality. Not addressing effects like (SBTC) would eventually lead to a rise in inequality.

In this general picture, we could see that innovation and inequality have a negative relationship, as one would expect. In general, the higher inequality, the lower innovation index a country has; in the other hand, the lower the inequality, the higher the innovation levels. But it is not possible to assure that this relation has been the same until now, or that it will behave the same in the future. As we can see in the graph, the cartesian pairs show this tendency, but there are cases from which we can not conclude the same, not at least without considering other factors.

Even though it is not statistically significant, it is interesting to look into the brazilian case in focus. We can see the graph bellow that inequality has been decreasing as innovation has been rising.

Figure 2: excel graph and formula, self-made – correlation between GII x WBGI



Despite being impossible to point a causation in such a small observation and most importantly ignoring all other economic variables (growth, employment, education, etc.), we can notice that in Brazil both variables are likely to have a negative relation if we just consider GII and WBGI. Even so, we highlight that such a conclusion can not be drawn off just these data. Further, we confirm the same trend in the following two data sets.

In sum, the combination of GII and WBGI shows a negative trend both in Brazil, in specific, and in general (worldwide).

5.2. WVS

The second analysis we draw is regarding other set of data: the world value survey. We take into consideration questions and answers of the fifth and sixth wave surveys (2005-09, and 2010-2014), focusing on Brazil.

The first three are related to one’s expectations and views about innovation in Brazil. The first one asked how people evaluate a great emphasis on development of new technologies, which 71% of the sample saw as good, 14% as bad, and 22% as indifferent, result very similar from the previous study, carried out in the 2005-09 wave. So, almost 3 out of 4 Brazilians think that innovation is positive. Likewise, when asked if science and technology make lives easier, healthier and more comfortable, 65% of people of the sample agreed. Almost the same percentage (66.5%) was found in the previous wave.

Yet a clear trend is found in the question if people think that the world is better/worse off because of science. In a scale from 1 to 10, one third put themselves in the worse half; so, two thirds would say the world is better off. Again, good odds in favour of science, a proxy of innovation.

In the other hand, when asked about the most serious problem in the world, 60% answered people living in poverty. Even though different concepts, inequality and poverty are very linked to each other. So it is not hard to realize that both inequality and poverty are important issues not just to Brazilian nationals but to world population in general. In the 2005-2009 wave, the same item got 70% of choices in Brazil, and 63% in the world average. In both waves, 15% said that people living in poverty were the second most important issue. Adding up to 85% and 75% of people saying that it is at least the second most important problem in the world.

This importance is corroborated by other result: when asked if income levels should be more equal, 26% of nationals strongly agreed; another 31% agree mostly with that claim, adding up to 57% inclined to an improvement in income distribution. Even so, a significant percentage of 41% disagrees, more inclined to say that larger income differences are necessary as incentive to individual efforts. Same levels were also found in the previous wave. This percentage is somewhat surprising, considering the level of income inequality seen in Brazil, the population is still quite divided between if income should be made more equal or even greater, as incentive. That perhaps represents how divided is the public opinion after a left(ish) party came into power of the first time in history.

Contrastingly, when asked about if the government should be responsible of providing for people, 70% of Brazilians are inclined to agree, in opposition for people should provide for themselves, with almost 28%. This indicates that people rely a lot on public policies in general, and probably in a similar way on reducing inequality.

Summing up until here, it is clear to see that science and technology are seen as positive by most of the sample. As the sample is representative, we could infer that the same can be said about the whole population. In both waves, results did not vary significantly. But one further question is more representative of the aim of this research.

In the 2005-2009 wave, Brazilians answered if they agree that there will be more opportunities for next generation because of science and technology. The results are the following:

This question can be interpreted as if people were answering if innovation will create more jobs than destroy, or in a broader sense, create more business opportunities than not. And a vast majority seems to agree that, counting positive and negative effects, the net effect expectation is widely positive. That way, people are not against innovative products, processes and services, but on the contrary, they are very welcome in society. More than that, people expect positive outcomes at the end, being possible to assume that the answer would be the same if one would replace “better opportunities” to “better jobs” or even “better businesses”. In that way, innovation would have positive effects on development. And it is not possible to assume today that great inequality can be set apart from development.

In sum, the second analysis allows us to understand that our intuition prevails among the Brazilian sample. Innovation is looked at with positive eyes, and inequality is one of the important mentioned problems. Yet, no important conclusion can be drawn on the effects that one has on the other with the mentioned answers. In that perspective, we extend the analysis to the next part.

5.3. Survey

The third part of the analysis is centred in a questionnaire designed for this study. The survey, as described in the third section, was responded by 50 people living in Brazil.

After being briefed on the concepts of innovation, NIS and inequality, the participants were asked what kind of NIS an unequal country tends to have. A majority of 72% agreed that it tends to be poor, with another 22% saying it would be average. Subsequently, only 6% saying it would be good or great. It could then be argued that people expect bad innovation system when looking at relatively unequal countries, what is corroborated by the first analysis.

In the second question, people were asked how do they view the current situation of Brazil's NIS. Again, a vast majority say that Brazil has a bad NIS, with 50% saying it is poor, and another 44% saying it is regular. This result is not in the same direction

as Chaminade *et al* (2009) and Chaminade & Padilla (2017), which puts Brazil in the category of fragmented or dual system. In that way, not anymore in an emergent or nascent type of system, but not yet a mature NIS. Accordingly, when we consider GII as a measure of NIS, Brazil is also in an intermediate position.

In the third question, when asked if a country with a good NIS would most likely become more or less equal, 80% responded it tends to be more equal, with just 2% saying it would tend to have more inequality. The other 16% answered that having or not a good NIS would not interfere in inequality levels. Again, answers not according to the mentioned scholars and with the GII and WBGI analysis.

In the fourth question, a question very similar to the previous were asked, in a different perspective. Surprisingly, 98% of people responded that a country with a good NIS tends to rise wages and with that improve equality levels. Only 2% answered that it tends to make the nation more unequal, due to high prices of novelties and the consequent low access to them. Other time, not according to theory and previous analysis.

When asked which of the 3 possibilities was the best way to reduce inequality, 60% of people responded that education is the best option; 36% chose redistributive public policies and affirmative and temporary policies, while the remaining 4% said that inequality is natural and inevitable.

Subsequently there is a question of what does a relatively unequal country tends to have related to entrepreneurship. 84% of people think that an unequal country tends to have smaller numbers of entrepreneurs; 8% think it is supposed not to make difference, and another 8% think that it should have more entrepreneurs.

It was also asked to people to mark the three main sources or drivers of innovation. The first noted issue was that, although 150 answers were expected, only 139 answered. The instrument did not make mandatory to answer all three choices, so some of the answerers did not choose three.

The result of this question is the following: the most chosen option was good institutions. In fact, the literature confirming the result is vast. New institutional economics (NIE) put emphasis in nothing but good institutions regarding long-term economic growth and development. With 37 votes, it overcame the second most chosen by 7 votes, knowledge diffusion. Regarding this last option, it is also often highlighted by the Innovation Systems literature the importance of knowledge diffusion in generating innovations.

The third most chosen option was good infrastructure, with 26 votes. Even though innovation is not directly connected to infrastructure *per se*, one possible

interpretation to this result is the lack of infrastructure found in Brazil, where all responders are from; in that perspective, a big part of the sample see this probably not as a driver of innovation, but as an impediment if good infrastructure is not found.

The fourth most chosen option was good market conditions: credit availability, good competition, low taxes, great consumer market, and so on. With 21 answerers choosing this option, it indicates that the demand side should be taken into account also, even though it is not within the three most seen answers, which was the question's aim. The fifth most selected choice was the company: employees' training, knowledge management, R&D investments, etc.; 15% of responders chose that option. Surprisingly, the least chosen one was patents and temporary monopoly of new products. This sample does not think this is an important issue regarding a good NIS. Contrastingly, the literature more often than not uses patents registrations as a proxy to innovation, so again people's perception is not according to the theory. Finally, 4 votes were given to an innate spirit of the entrepreneur is what drives innovation.

The following question demonstrates the current national and worldwide political situation we are facing. When asked if innovative actions should be aware of resulting inequalities and should the State adopt public policies regarding the prevention and/or fight against these effects, or if should the State only determine general rules and let the "invisible market hand" take care of the rest, 50% chose each answer. There is a current process of division in Brazil's politics, as it is in several regions of the world that separates people roughly into leftists and rightists. When given only these 2 options, a so unexpected half chose each side. It can be a result of bias to extremes by the survey itself, but it is not to say that it is not the present situation, that could lead to another thesis in political sciences.

When question about the importance of inequality reduction, an overwhelming majority of 98% think that it is at least socially positive. 88% agree that, besides that, it is also positive for economic growth. Only 2% of the sample thought that decreasing inequality would prejudice economic growth.

Ultimately, the most seminal questions were left at the end of the survey, with the intention of appropriating better the learning curve of both subjects. The first was about the effects that innovation has on inequality in Brazil. With 66% or approximately two thirds of the answerers responding that it hinders innovation; 24% chose the option that innovation depends on several matters, many of them more important than the level of inequality. 8% agreed most with the assertive that said that poverty is harmful for innovation, but inequality

is a necessary incentive to innovation, and the remaining 2% said it does not have affect on innovation levels.

These numbers show that most people see that inequality affects negatively the levels of innovation, and that same conclusion can be draw off the first analysis.

A yet significant share, almost one quarter of the sample, said inequality levels affect innovation, but with other more important causes. Indeed the GII is calculated taking into consideration a broad spectrum of variables, divided into inputs and output categories. Within the input items, inequality levels are not considered directly. But not only intuition, but high inequality levels are connected with several different problems, i. e., low education levels, making it hard to distinguish which one is cause and which is consequence (TED talk guy). Several of those variables have clear effects on the inputs of innovation and in the system in general. It is therefore not hard to see that inequality does have a clear downward effect on innovation levels. And policies that foster equality could indeed improve the quality of the system, spurring indirectly innovation, and with that, growth and development.

Finally, at the question on how innovation affects inequality, the answers were in the other direction: the innovation increases equality levels. Nevertheless, these answers could be biased by the wording used in each option. Even so, the results are the following: 66% of responders said that innovation would reduce inequality, as new products and services, public ones included, available to all, would improve the population's general conditions. Perhaps the condition given of "available to all" might have been interpreted as if it was granted, and not a precondition. Even so, in the same line of George *et al* (2012) and Cozens (*in* Lundvall *et al*, 2009, ch. 3), if that is taken care of with the right policies, it would be indeed the case.

In addition to questions with alternative answers, the last question left room for one open ended question, where the answerer could write anything he or she would like, was it related to both issues, or even to the instrument itself. Four of 14 answers have mentioned some issue related to the instrument. One of them said that he or she did not agree completely with none of the possible answers in more than one question, but did not refer which ones; other responder demonstrated some knowledge about the issue, arguing that he or she did not see any relation between the two macroeconomic themes. The same person supported his argument with nations examples. US has high inequality and high innovation, Brazil presents high inequality and low innovation level; Sweden, less unequal and highly innovative country, Cuba in the other hand has great equality and low innovation levels. Yet Israel, he or she still argues, has high inequality and high levels of innovation. This work agrees that this answerer has good points; in fact, US, Sweden were addressed at the first analysis highlighting exactly

the extremes: US with high innovative index and Sweden (as the rest of Nordic countries) with the lowest inequality levels. As measured by Gini index, however, Israel is relatively far from having a high inequality level, so that example does not corroborate the initial idea. Even so, this work does not try to address the immediate relation between inequality and innovation. On the contrary, it tries to demonstrate that this connection is mediated by several affairs, and both affect and are affected by growth.

Confirming that open-ended questions are enriching, other comments were added. One answerer argued that equality of opportunities is in fact the main source of true equality. And he or she mentioned also that the ideal way to reduce inequality was to provide people with temporary measures that would conduct them towards equality of opportunities. He or she did not mention the connection to innovation, however. Other responder argued that people should look at innovation as a group necessity, and the more we work towards innovative paths the better. And he or she said that inequality is one of the difficulties that hinders people to feel as part of a group. Interesting though, perhaps more related to sociology than economics, but still, showing that inequality prevents innovation from happening.

Other answerer commented that inequality rises at moments of economic crisis. That is something that this study did not look into, but the intuition says it is most likely true.

One last commented answer looked at the relation of inequality and innovation through another philosophical view. He or she mentions that equality is a necessary precondition to scientific, social or co-relations innovations. Inequality, he or she continues, “creates a gap that hinder communication, exchanges, and the acceptance of new ideas and concepts” – aware of the difference of world novelties and the introduction of an already developed product in a new place. For this answerer, the most important inequality is in power relations, and we are currently facing a resurgence of old ideas. It is not hard to agree with that opinion.

Surprisingly, the conclusion taken from the survey in Brazil points out that high inequality prevents innovation from coming about, but innovation diminishes inequality. So, in one direction innovative products, services and processes would decrease inequality. This assertive, as Cozens (2008) and George *et al* (2012) put it, is just supposed to happen if the right policies accompany innovations. There are even further studies in the literature in the social innovation area, where such innovations could indeed improve equality levels, but are not the focus of this study. In that case, indeed, innovations would diminish inequality. A good example of this is the leap that some African countries took when they skipped the Wi-Fi technology and infrastructure, going directly to 3G and even 4G internet connexions. Escorted

by low prices of smartphones, it was an effective measure that showed it is possible to innovate and reduce inequality at the same time.

6 Conclusions

Despite of the complexity of this relationship strongly mediated by growth, but also having effects and being affected by the levels of employment, education, knowledge-building and consumption, among perhaps several others economic variables that could influence and be influenced by both subjects, and the relationship between them, we can infer that the relationship between innovation and inequality is negative. While we see high levels of inequality, we see low levels of innovation and vice-versa.

We have aimed to analysed inequality and innovation relationship through the literature and through 3 different glasses. The first with GII and WBGI, the second one with the WVS and the third one with the survey. At the end, more questions than answers were found. Yet, We could find a possible conclusion at the policy level: specially in the developing world, but moreover world-widely, It is not possible anymore to address economic growth without addressing also inclusive development. It seemed in the recent years that the world was going in that direction, but recent facts (i. e. Brexit) indicate that this path is far from unanimous. If not for more noble reasons, transforming the world weakest economies into more prominent markets should be enough reason to do so. Beyond taking account of the numerous issues connected to inequality, policy makers should realize that innovation has been one powerful way of economic growth in the developed world for quite a long time, and for a significant part of the developing world growth. Aware of the challenge, it is possible to innovate generating growth and including more people at the same time, as theorized by literature (George et al, 2012; Cozens, 2008; Chaminade & Pérez, 2017).

Yet, some final interpretations could be infered by this analysis:

(1) We found indication that inequality hinders innovation in general, and Brazil was not different in the last decade. We find that education is at the centre of knowledge building, which in turn links to innovations as inputs and, at the same time, as an enabler of inequality reduction; in fact, a “fundamental point (is) that economies only develop through their people becoming more knowledgeable” (Metcalfe & Ramlogan, 2008).

(2) It is well-known that institutions set the framework of the whole economy, and path-dependency is hard to overcome. Brazil seems to demonstrate this clearly in the last decade; therefore, despite of the difficulties and complexity, this must be addressed to spur innovation as well as to diminish inequality;

(3) the policies should be holistic enough to embrace as much parts of the NIS as possible, as well as to address potential inequality generators, being aware that this is especially difficult in developing countries (Chaminade & Padilla-Pérez, 2017).

(4) Ultimately, the main findings of this empirical analysis indicate that innovation is not the main responsible for the Kuznets curve not being empirically observed, as the recent trends show an upward trend in inequality worldwide, but especially in the developed world, which is somewhat surprising. China, India, Indonesia and Brazil have showed some recent improvements in income inequality, but that has not been enough to change the general trend. A great array of variables influence inequality; even though innovation is an important one, it is not the only. Maybe not even one of the main.

Finally, the remaining questions are abundant. Is this relationship in anyway possible to be generalized? When looking at long run in Brazil, both to past and to the future, are the same inferences possible? How much of one can be explained by the other? It seems that this subject is growing at the literature. It is not for sure that that we will fully understand this relationship soon, but if we could, the right policies could be addressed and the south could develop faster and better.

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Appendix A