CLIMATE POLICY INITIATIVE
NÚCLEO DE AVALIAÇÃO
DE POLÍTICAS CLIMÁTICAS
PUC-Rio

High Productivity Agricultural Techniques in Brazil: Adoption Barriers and Potential Solutions

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October 2013

Executive Summary

Descriptors

Sector	Land Use, Agriculture
Region	Brazil
Keywords	agriculture, no-till farming, Direct Planting System, social learning, soil dissimilarity

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About the Executive Summary

This document presents the main findings of "Geographic Heterogeneity, Social Learning, and Technology Adoption: the Direct Planting System in Brazil" by Assunção et al. (2013). Please refer to the paper for a comprehensive discussion of the study.

Acknowledgements

Ana Ribeiro and Fabio Magrani provided excellent research assistance. We acknowledge Clarissa Gandour, Romero Rocha, Rodrigo Soares, Dimitri Szerman and Alban Thomas and for their helpful comments. We also thank EMBRAPA and IBGE for methodological support. Lastly, we are grateful to Manoel Henrique Pereira, head of the Brazilian Federation of Direct Planting, for kindly welcoming our team and answering our questions.

About CPI

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Our work helps nations grow while addressing increasingly scarce resources and climate risk. This is a complex challenge in which policy plays a crucial role.

Executive Summary

A no-till farming method called the Direct Planting System (DPS) is one of the most important developments in agriculture in the past decades. Farmers who adopt the DPS produce higher crop yields at a lower cost while generating lower carbon emissions from their farming, outcomes that benefit both farmers and the climate. Adoption of the DPS does not have any relevant upfront costs and results in more reliable yields than traditional farming. However, nearly forty years after the introduction of the DPS in Southern Brazil (in 1971), adoption levels remain very low throughout the country: Only 10% of Brazilian farmers reported using the system in 2006 and the adoption rate is the same for both small farmers and large-scale operations. Given the unambiguous advantage to farmers of the DPS, this low adoption suggests there is some kind of barrier to the spread of this method.

In this study, we find that social learning — i.e. farmers learning new methods from their neighbors and peers — plays a major role in the spread of the DPS. We also find that in any given municipality in Brazil, similarities or dissimilarities in soil composition directly affect social learning, and thus, uptake of the technology: The more similar the soil within a municipality, the easier the spread of social learning. This is particularly true for areas with intermediate levels of DPS adoption where there are enough farmers to share their knowledge with their peers.

Finally, we find that other ways in which the DPS spreads (such as formal training) reinforce social learning mechanisms as they raise DPS adoption to intermediate levels.

These results have two direct policy implications:

- First, in order to increase agricultural productivity, it is not sufficient for policy to address innovation, develop business models, and marginally subsidize adoption. It must also disseminate information on new techniques and their associated technologies. Our results suggest that an itinerant training process, moving across municipalities over time, can support the spread of knowledge and adoption. In fact, one of the alternative channels of dissemination shown to have an impact is a private training center — Clube da Minhoca — run by the Brazilian Federation of Direct Planting, that works temporarily in municipalities where the DPS has low adoption levels. Our analysis suggests that public policy could follow this private sector example, to raise DPS adoption levels to where the technique can more easily spread through social learning.
- Second, the impact of such efforts is decisively affected by soil composition in any given municipality. Where soils are more similar, learning from peers becomes easier, and thus efforts to increase adoption can provide an initial spark that is then fueled by social learning. It follows that public policy should take into account geographic diversity and first target areas where social learning can go farthest in order to be as cost-effective as possible.

This summary will begin with a brief explanation of our methodology and then detail each of our three main results in turn with particular emphasis on their policy implications.

An empirical evaluation of how and where the DPS has or has not spread can shed light on two important points.

First, a better account of the mechanisms for disseminating information on new technologies and techniques in the Brazilian agriculture sector can help identify ways of improving agricultural productivity. For example, current policy focuses on innovation of new technologies, but, to improve adoption of new technologies, it might also be important for policy to focus on how technologies and techniques are spread to farmers, for instance, the action of cooperatives, technical assistance, or rural training programs.

Second, as one of the main ways in which the Brazilian government aims to hit targets for reducing carbon emissions from the agricultural sector, the Agricultura de Baixo Carbono program (ABC - Low-Carbon Agriculture), implemented in 2010, provides subsidized rural credit to farmers for implementation of the DPS. However, low-cost credit cannot drive DPS expansion if non-financial restrictions are significant.

Methodology: Social Learning, Soil Types, and DPS Adoption

In this study, we raise and test the following hypothesis: Social learning performed a significant role in the diffusion of the DPS. We define social learning as farmers learning a new method from neighbors or peers who have already adopted the method. In general, testing for the presence of social learning demands information on social relationships, which is expensive to gather (and often impossible in large-scale agriculture).[1] Instead, to determine the importance of social learning, we explore the impact of a specific deterrent, or, in other words, a factor that frustrates the learning process. In this case, soil dissimilarity is considered a major deterrent to social learning — since the DPS needs to be adapted to specific soil conditions (for example, higher soil temperature may call for a thicker layer of residue to be left on the surface), lower soil similarity within a municipality makes it more difficult for farmers to learn from their peers' previous experiences.

Our method is derived from a simple observation. If social learning is an important channel of diffusion, then soil diversity (the deterrent to social learning) and DPS adoption levels would have a specific relationship. What we would expect to see is that when adoption levels are too low, the impact of soil diversity on DPS adoption should be zero: Social learning cannot take place where there is no one to learn from. When adoption levels are too high, the impact should again be zero as social learning has already overcome soil dissimilarity. The impact should be highest for intermediate levels as social learning is possible, but feeble. In order to isolate the effect of soil dissimilarity, we also take into account many other factors that might affect adoption — such as geographic (rainfall, temperature, land gradient) and socioeconomic (educational levels, farm size, etc) variables.

We note additionally that this method may be used to identify social learning in other contexts and should prove particularly relevant in large-scale studies when gathering information on social relationships is not viable. Moreover, and despite the fact that the spread of new methods and technologies takes place over time, our method may be applied even in the absence of time series.

Soil Diversity Data

Brazil, as the fifth largest country in the world, has many different types of soil both within and across municipalities. To classify these differences, we use a map of soils developed by the Brazilian Company for Agricultural Research that shows the distribution of different types of soil over the country based on the chemical composition of each type of soil — for example, the levels of iron or organic matter.[2] We use this information to determine how much of each municipality is covered by each kind of soil and use these shares to build a measure of soil concentration, or similarity, for each municipality (see Figure 1).For example, a municipality covered by only one type of soil has maximum concentration, and hence minimum dissimilarity.

Results

Soil Diversity Decreases DPS Adoption Levels

Our results show that soil dissimilarity is systematically related to DPS adoption. These results may be seen on the maps in Figures 1 and 2. Figure 1 shows the distribution of dissimilarity across Brazil, with a detailed view of South Brazil in the map on the right: Darker areas represent municipalities with higher soil dissimilarity. Figure 2 shows DPS adoption levels, again, across the country and in South Brazil: Darker areas have higher adoption levels. A visual inspection shows that lighter areas in Figure 1 are associated with darker ones in Figure 2. South Brazil presents the highest adoption rates in the country.

Our results corroborate this visual analysis. On average, Brazilian municipalities are covered by 1.72 types of soil. We estimate that adoption levels would be 7.1% higher if Brazil were covered by only one type of soil. Thus, we show that DPS adoption levels are affected by soil composition.

Impact of Soil Dissimilarity is Highest for Intermediate Adoption Levels

We turn now to the impact of soil dissimilarity on DPS levels over different ranges of adoption.

We find that soil dissimilarity has no impact on DPS adoption for both low and high adoption rates:

- For adoption levels up to 18%, we find the impact to be zero, which is line with the prediction that social learning cannot take place

1 A well-known example is the study of technology adoption in pineapple farming among villagers in Ghana.

2 This map is based on the Brazilian System of Soil Classification, also developed by the Brazilian Company for Agricultural Research.

Figure 1

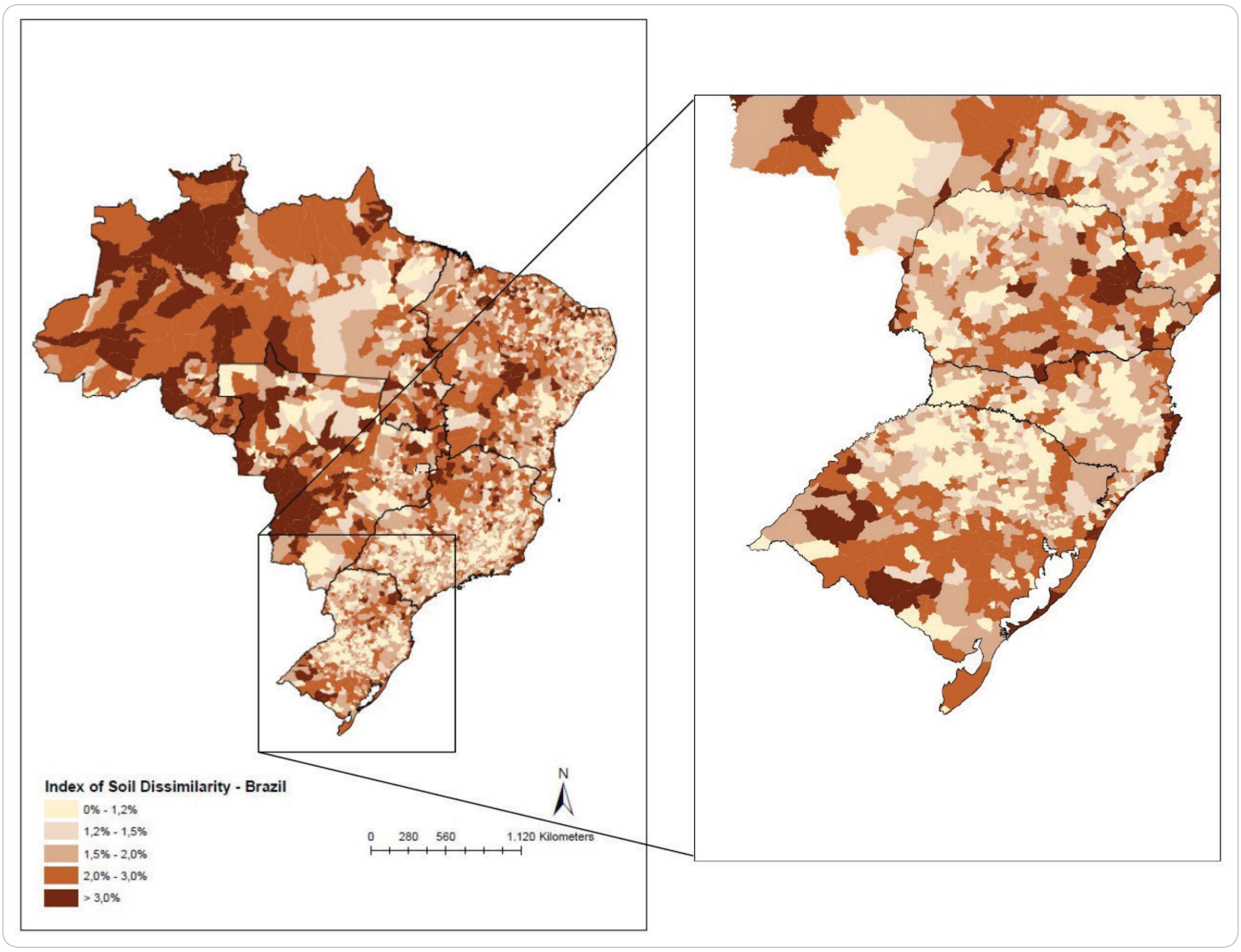
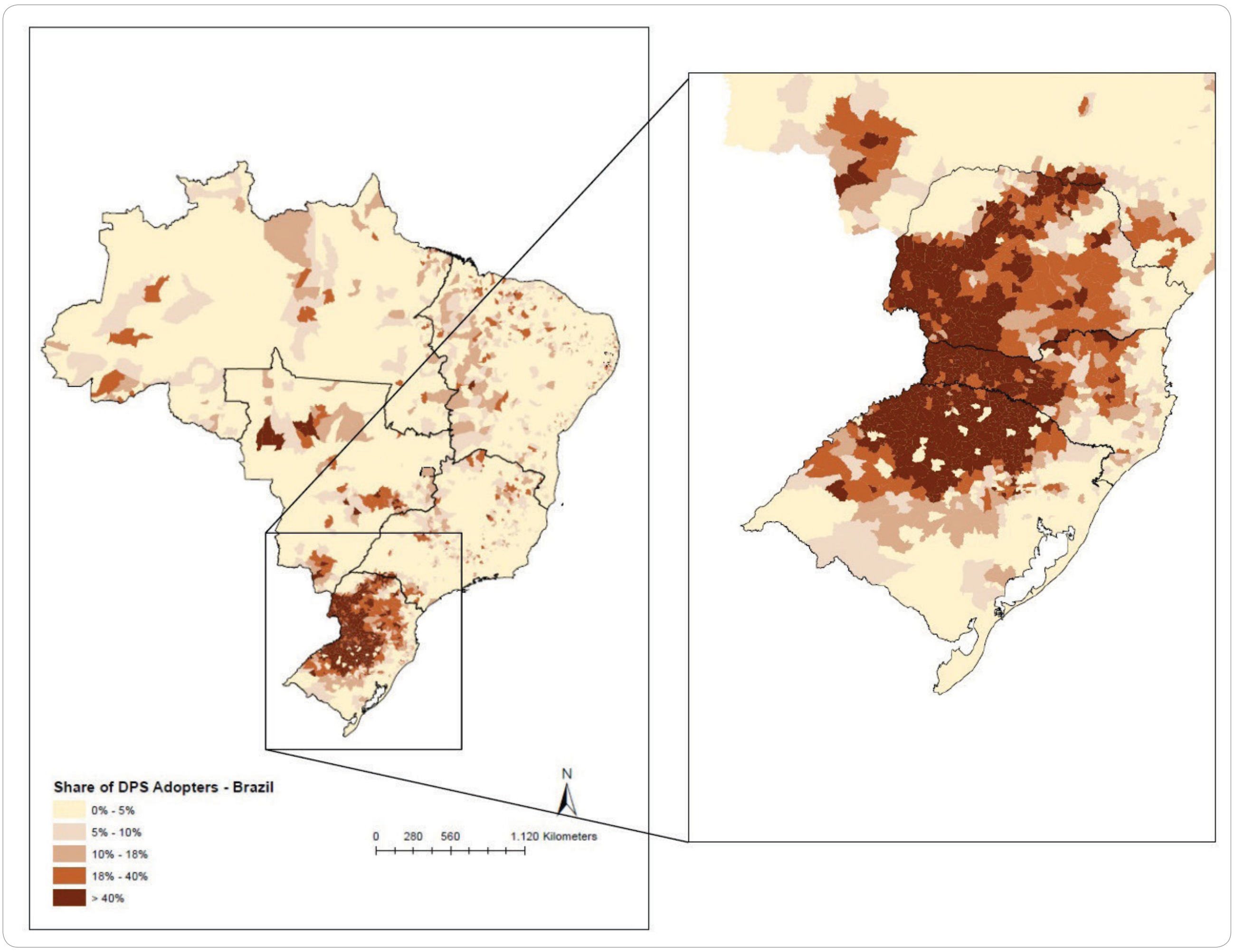


Figure 2



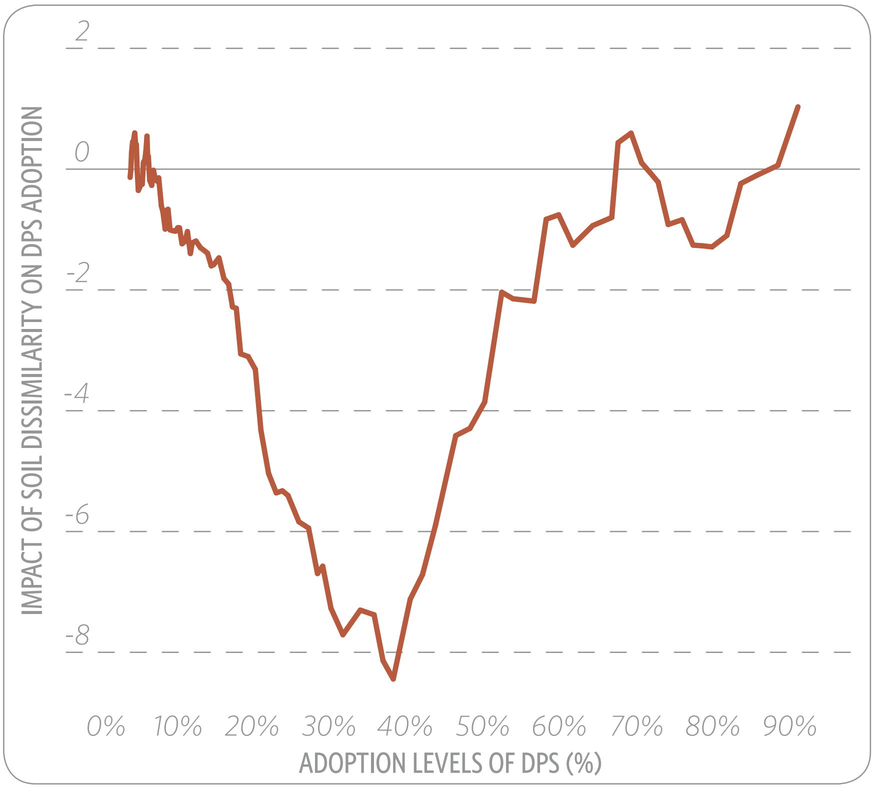
when adoption levels are too low as there is no one to learn from.

- Above 50%, the impact is again found to be zero: Dissimilarity is no longer a barrier when the share of adopters is high enough.

For intermediate rates (between 18% and 50%), however, soil dissimilarity has an important impact: A standard increase in soil dissimilarity decreases adoption levels by more than two percentage points within this range. This effect is highest when the adoption level is close to 40%, when it reaches 5.8%.

These results may be summarized in Figure 3. The horizontal axis represents DPS adoption levels, and the vertical axis shows the impact of soil dissimilarity on DPS adoption. The U-shaped format of the depicted curve means that the impact is most important for intermediate levels of adoption.

Figure 3



These figures have two interpretations. First, social learning is a significant channel for the spread of the DPS in Brazil. Second, soil dissimilarity has had a significant deterrent effect on social learning – and hence on DPS adoption.

Together, our first two results suggest a clear policy implication: Public investment in training should take into account soil dissimilarity and current adoption levels. If resources are limited, public policy should focus on regions with high soil similarity and low adoption levels to raise them to intermediate levels where social learning takes place more easily. In Figure 4, we identify 606 municipalities with relevant agricultural activity where these two conditions are met.

The Effect of Alternative Dissemination Channels

In theory, alternative dissemination channels like the presence of co-ops or private training centers may affect social learning in one of two ways: They may act as a substitute for social learning or they may complement social learning. If the effect is the former, it follows that as alternative dissemination channels are added, learning from peers becomes less necessary.[3] With the latter possibility — a complementary relationship — when adoption levels are too low for social learning to take place, the use of alternative channels may raise adoption to a level where social learning is viable.

Analysis on whether alternative dissemination channels are a substitute for social learning has only been available for small-scale experiments. We revisit this issue empirically in our large-scale setting. Our findings suggest that, in the case of the DPS in Brazil, social learning and alternative channels are in fact complementary and alternative channels can increase adoption to levels where social learning becomes viable. In municipalities with many co-ops or that are close to training centers, the effect of soil dissimilarity is about three times higher than the average. The direct impact of these channels is also positive. Co-ops increase adoption levels by 18.6%. Municipalities close to training centers have adoption levels 8.6% higher than other municipalities.

A relevant and illustrative example comes from the Southern region of the country, where farmers who adopted the DPS established a private diffusion center known as "Clube da Minhoca" (henceforth "CM") in 1979. The name of the club translates as "Earthworm Club" — as the presence of earthworms is a sign of soil vitality, which is boosted by the DPS. CM is an association that aims to spread the DPS by adapting it to different environmental conditions and by promoting

3 Again, this is illustrated by the study on technology adoption in pineapple farming among villagers in Ghana.

meetings between adopters and non-adopters. As of 1982, branches of the CM started being created over the country. In most cases, these branches were established only temporarily so as to introduce DPS into a new locality. After the system spread to a given level in that locality, social learning would become viable, and the local branch would close and move on to a different place. This procedure is still operational and is one of the main drivers of the expansion of the DPS in Brazil.

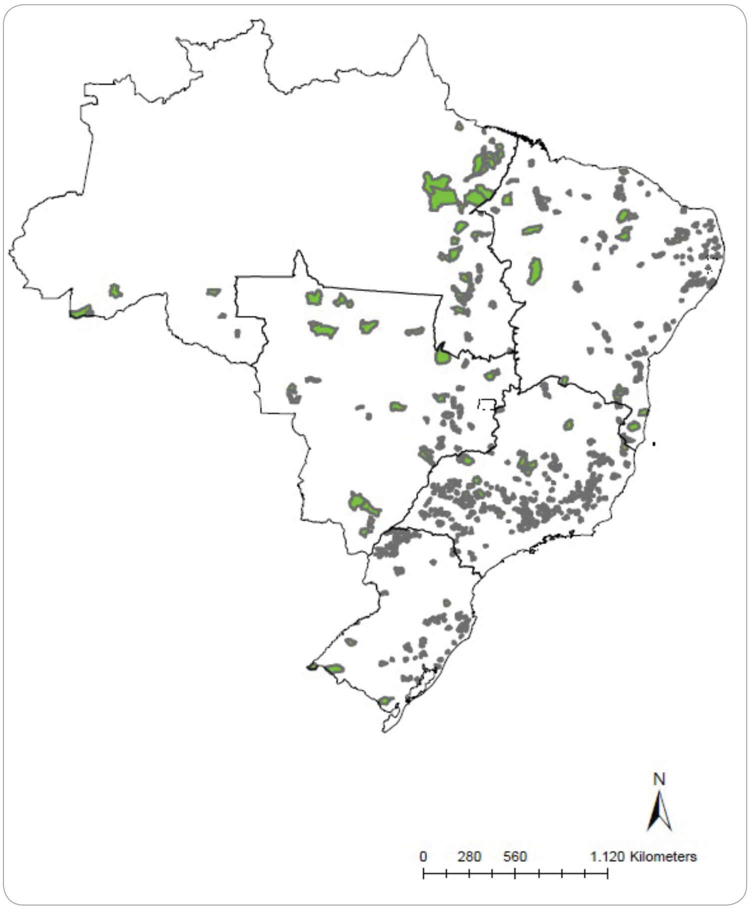
These results suggest another set of policy implications. First, public investment in training can reinforce social learning. Our results highlight that social learning is an important channel in the spread of new methods and technologies in agriculture. It follows that the easier it is to learn, the faster new systems will spread. There are many policy tools that can help achieve this objective: improved education; alternative dissemination channels; collaboration between farmers and research centers; and using farmers' associations to spread knowledge.

More specifically, our results highlight that the initial phase of the spread of new techniques is the most important one — especially if environmental differences are low. Afterwards, learning from peers will develop naturally. It follows that the government needs only establish temporary training facilities, which may move on to different regions after adoption levels reach a certain threshold (which will depend on environmental conditions).

Conclusion

We presented evidence that environmental characteristics (soil dissimilarity) affect the adoption of a new technology (the Direct Planting System) in Brazil. Moreover, this impact is consistent with the hypothesis that learning from peers is a major channel by which new methods spread. Policymakers should then take into account environmental conditions when designing tools to promote adoption of new techniques, and should provide training and other learning possibilities that reinforce social learning.

Figure 4



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