Tropicalizing Sustainable Bioeconomy: Initial Lessons from Ecuador

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Abstract Sustainable bioeconomy is being revised in tropical megabiodiverse developing countries. Given competing economic interests and development inequities, biodiversity may require becoming a strategic and central resource in national economies to ensure political feasibility of bioeconomic models. This paper attempts to address the need to document alternative approaches to transition to sustainable bioeconomy in the context of extractive economies in tropical and megabiodiverse developing countries. Using a case study approach, it reviews the Ecuadorian experience to developing a bio-industry value chain as an institutional arrangement that can enable a more efficient and integrated use of biological resources towards a sustainable and resilient economy, while addressing structural development and biodiversity protection challenges. Knowledge generated from this research can assist policymakers working on optimal design of instruments aiming at unraveling the full potential for biodiversity as a key resource in development strategies of tropical megabiodiverse countries.

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1 Introduction

Bioeconomy is receiving increasing attention as an alternative to a global transition to sustainable development. Countries across the globe more and more confront development decisions that require arrangements to align socio-economic dynamics in harmony with nature while addressing poverty challenges. These decisions typically require consideration of, among others, bio-physical, political and economic factors. Bioeconomy needs to address those challenges in order to become a sustainable economic model (Sillanpää and Ncibi 2017). The following chapter explores the tropicalization of bioeconomy for unraveling the biodiversity potential and catalyzing a transition to sustainability in a tropical megadiverse country—Ecuador.

Bioeconomy is defined as the industrial transition to the sustainable use of aquatic and terrestrial biological resources in intermediate and final products for economic, environmental, social and national security benefits (Golden and Handfield 2014). It incorporates a set of economic activities related to the research, development, production and use of biological products and processes (OECD 2009). Regardless of different definitions, there is evidence of its global importance. Unlike the declining trend in investments in sectors such as oil, investments in bio-industry sectors show a sustained growth. For instance, US and European investments in bio-technology since the late 1990s have grown by about 20% (Hill 2000). In Europe, the bioeconomy sectors are worth 2 trillion euros in annual turnover and account for more than 22 million jobs (about 9% of the workforce) (EU 2012). At the beginning of 2015, public-private investments reached more than 2.1 billion euros (Piotrowski et al. 2016). Improvements and innovative adaptations of the bioeconomic model—by economies in different development stages—seem to be significant drivers of its sustainability and globalization, which is of course strategic by nature.

Tropical megadiverse developing countries face increasing pressures to biodiversity conservation during on-going development efforts. While countries like Ecuador have made significant efforts to combat poverty during the last decade, recent research highlights the increasing rate of biodiversity loss and the need for ambitious policy approaches to address it (WWF 2016). Megadiverse countries with sufficiently large domestic markets to develop cost effective manufacturing capacities at different stages of the supply chain may be more interested in bioeconomy. However, in many tropical developing countries several non-technological and economic factors may stand in the way of bioindustry: insufficient technical knowledge and absorption capacity to produce innovative technologies locally, insufficient purchasing power to acquire innovative products, and insufficient market size to justify local production units (Jha 2008). However, a more important consideration is perhaps the existence of preferences toward bio-products: a real domestic demand. This would be essential to sustain the economy until it redeems its export potential, starting with markets sharing similar demand structures, following Linder's hypothesis.

Ecuador is perceived to follow a process of endogenous socioeconomic transformation, driven by public policy (Cypher and Alfaro 2016). Empirical evidence has revealed a tendency towards an increasing imbalance between exports and imports in physical terms for Ecuador (Vallejo 2006), as well as other Latin American countries (Giljum and Eisenmenger 2004). Ecuador's physical deficit, when exported tons exceed imported tons, was the highest and did not decrease between 1980–2000, when the export sector was mainly based on oil and biomass (Russi et al. 2008). In response to this and other threats, the country has created an innovative policy arrangement aimed at promoting biodiversity to achieve a long-term economic performance that diverts from the middle-income trap and oil-dependence.

This chapter uses an institutional economics framework to study a institutional arrangement for bioeconomy in Ecuador. It follows previous research arguing that development models must move away from narrow concerns with macroeconomic imbalances and poverty-alleviation safety nets to confront head on the structural inequalities, while addressing sustainability (Rival, Muradian and Larrea 2015). It also builds on literature underpinning the critical importance of fostering specific uses for biodiversity as means to ensure its conservation and address rural inequities (Espinel 2009; Golinelli et al. 2015).

To organize our analysis, we use the *Situation, Structure* and *Performance* (SSP) framework articulated by Schmid in 1978 (Schmid 1987). We first describe key macroeconomic elements of the Ecuadorian economy, the Situation. Next, we describe key attributes of the National Strategy for Biodiversity, the Structure, followed by predictions concerning the operation of those structures with emphasis on rural development, the Performance. These predictions will be evaluated using evidence from field research, previous experience, and other data. We then go on to discuss in more depth the expected relative performance of these structures in light of alternatives changes, including strengths and weaknesses. The chapter concludes by identifying key lessons for policy makers and possible avenues for future research.

2 Tropicalizing Bioeconomy

Tropical megadiverse countries have many singularities from legislative, historical and geographical development gaps requiring innovative models of bioeconomy or its adaptation ("tropicalization"). In the case of oil-based economies, the model's complexity increases and requires political feasibility through the material delivery of benefits to equate and weigh-off conflicting interests detracting from the competitive advantages that biodiversity-based knowledge and bio-industry development offer. Identified challenges to tropicalize a bioeconomy are presented in Fig. 1.

Any configuration of bioeconomy should account for complex interdependencies and trade-offs between the relative participation of the sector in GDP, labor migration, deforestation, biodiversity loss, industrial and services sectors' development. Tropical megadiverse countries emphasizing biodiversity in a transition to sustainable patterns of production have the potential to materialize economic benefits through employment, wealth creation and higher level of self-sufficiency for farm and non-farm rural communities (Golden and Handfield 2014), which can in turn have a positive effect in mobilizing societal support in the initial stages of implementation. One option for the bioeconomy to play a critical role in development of tropical megadiverse countries is to address rural sector challenges in the context of implementing the United Nations 2030 Agenda for Sustainable Development. Furthermore, existing literature highlights the role of the agricultural sector in providing a source of informal social protection in the form of food security and the conservation effect on biodiversity of small-farming (see Espinel 2009). Thus, transition strategies to bioeconomy can also be understood as an indirect mechanism to incentivize the sustainable provision of these public goods.

Ecuador, particularly, faces challenges in converging with developed nations, due to its inability to complete the productive transition from low value-added sectors (commodities and natural resource and labor-intensive manufactured goods) to high value-added sectors (technology-intensive manufactured goods) (Domínguez and Caria 2016). In a well-developed strategy, Ecuador may be able to offer initial lessons to the world's sustainable bioeconomy policy approaches. While developed countries' efforts to achieve a transition to bioeconomy heavily rely on bioenergy and biomass (Sillanpää and Ncibi 2017), the Ecuadorian strategy

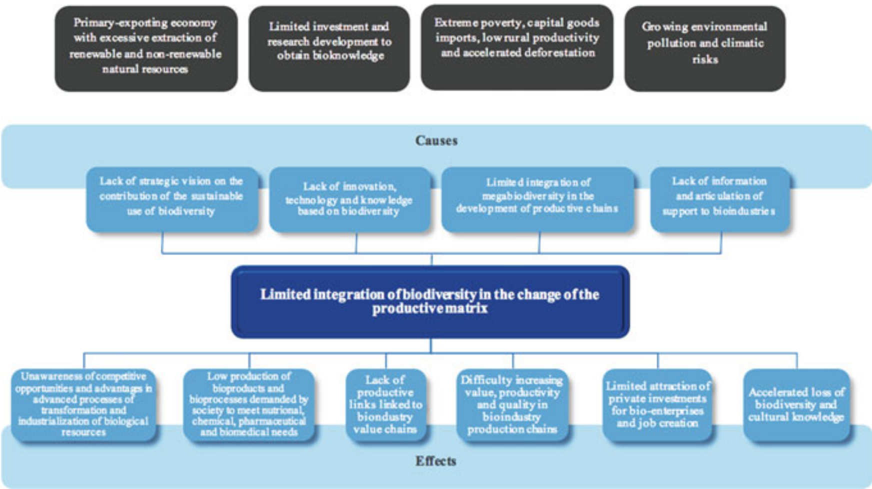

Fig. 1 Summary of identified challenges to tropicalized bioeconomy

focuses on biodiversity as a key building block of a sustainable economy, by means of—not limited to—knowledge-intensive products. This should add to the sustainability of the bioeconomy model proposed in Ecuador. From the recognition of nature's rights in its constitution, to the promotion of the concept of net avoided emissions at the United Nations Framework Convention with the Yasuní-ITT Initiative, Ecuador's innovative approach to bio-industry and bioeconomy is a demonstration of its restless efforts to achieve sustainability and poverty eradication.

Some authors argue for a reassessment of the role that biodiversity should play in the development plan and the national strategies to eradicate poverty and change the productive matrix in a transition from a primary extractive economy to a tertiary one based on knowledge (see Walsh 2010). The expected results of a strategy for bioeconomy may be observable in the long run, yet the industry is starting to acknowledge the need for further development of bio-industry value chains. Initial lessons from Ecuador can offer some insights into combating biodiversity loss and putting into value its central role in transition to other megadiverse tropical countries facing similar economic trade-offs, historical inequities and conflicting interests.

3 Method

Institutions structure incentives, shape people's beliefs and preferences, and introduce predictability to human interaction (Schmid 2004). As such, human institutions (i.e., ways of organizing activities) may contribute to biodiversity loss (Barbier et al. 1994). Institutions and biodiversity protection may thus be evaluated and compared in contexts that consider institutional performance and relationships (Wells 1998). Focusing on institutions can help policymakers evaluate alternative arrangements for achieving sustainable development and poverty eradication.

3.1 Situation, Structure and Performance Analytical Framework

The Situation, Structure and Performance (SSP) framework (Schmid 1987) allows for an analytical institutional impact assessment. By observing "variables" in their context (i.e., the situation), which are taken as given, interdependencies arising from characteristics of the "good" and actors involved in "transactions" are identified. These transactions, the interplay of individuals and their contexts including ever-present costs, are the unit of observation. Institutional impact analysis of an established situation (e.g., the sustainable use of biodiversity to foster economic development) allows for comparing institutional alternatives (i.e., structures) that may impact interdependencies related to the good(s) and individuals (Boerrke 2001). That is, by holding the "situation" constant, alternative "structures" may be evaluated to predict relative "performance" in terms of substantive measures (e.g., economic outcomes and distributions). Evaluating presumed or actual performance allows the articulation of conclusions and/or insights concerning the alternative structures' likelihood of achieving targeted social goals.

Situation

Despite significant progress in reducing inequality, particularly since 2000, Ecuador shows evidence of multidimensional inequalities, including socioeconomic, ecological, and power asymmetries, and on their historical and transnational character (Braig et al. 2015). We now present the macroeconomic variables that influence the "transaction" under study, i.e., the provision of bio-based goods and services in Ecuador, enabled by the sustainable use of biodiversity. Namely, we will look at last decade's performance of the most relevant figures under two subtopics: Growth and inequality (GDP and Gini Index) and Structural changes in the economy (agricultural sector as a percentage of GDP, consumption patterns, agro-trade balance). Given its bio-based nature, we look at the agricultural sector as a proxy to assess the sustainability of prevailing bio-economic sectors. Before moving on to the Structure, we will summarize future perspectives that authors have elaborated, based on the aforementioned figures, regarding socio-ecological transitions in Ecuador.

GDP growth and inequality

On the one hand, Ecuador's 2007–2014 period showed strong growth (4.3%)—compared to 1990–2001 (2.4%)—trade surplus (9%), and moderate inflation (4.8%) (BCE 2015). The favorable terms of trade for Ecuadorian commodities, such as cacao and oil, as well as large investments in public infrastructure strongly added to growth. At the international level, commodity prices remained high, expanding mining and export agriculture activities. Both terms of trade and financial inflows pressed for an appreciation of the real exchange rate of around 10.3% between 2007 and 2012 and 8% in 2012–2016 (BCE 2012, 2016).

The strong economic growth observed since 2007—with the exception of 2009—has morphed into an economic downturn. The most recent forecast by the International Monetary Fund shows negative growth from 2016 until 2020 and a cumulative fall in GDP of almost 7% (IMF 2016). Between 2009 and 2016, private external debt increased by USD 2.1 billion and public debt, by USD 18.3 billion (BCE 2016). The 7.8-magnitude earthquake that hit Ecuador in April 2016 represented an even greater challenge to public finances than low oil prices or plummeting export revenues due to unfavorable exchange rates. Among several other measures, the Solidarity Bill increased the Valued-Added Tax by two percentage points in order to collect additional resources for reconstruction. As a result, tax collection decreased by 8% between 2015 and 2016. Furthermore, between the first quarter of 2016 and the same period of 2015 (t/t-4), real GDP's variation was −4% (BCE 2016).

Regarding inequality, the Gini coefficient lowered from 0.57 to 0.45 between 2000 and 2016 (BCE 2016). Inequality between groups has also decreased. The ratio of household per capita income between urban and rural households fell from 2.38 in 2005 to 1.69 in 2014 (SIISE 2016). A decomposition of the Gini fall over 2002–2012 in Ecuador suggests another explanation: a drop in the skilled-unskilled wage ratio (Cornia 2014). This reflects a 9% reduction in overall poverty between 2001 and 2014 (i.e., from 54.9 to 33.6%) (Cypher and Alfaro 2016). Some authors, however, have argued that once the commodities boom ended—worldwide oil prices reduced from USD 109,45 in 2012 to USD 26,5 in 2016—government policies aimed at reducing inequality turned out to be unsustainable and inequality may start to rise again (see Gachet et al. 2016). That is, reductions in inequality in Ecuador may have been subject to temporal characteristics of resource booms.

Structural changes in the economy

The main drivers of Ecuador's growth have not resulted in productivity gains nor in an increase of the technological content in agricultural and industrial products. Much to the contrary, the boom has been central in the domestic service sector. The net trade deficit of manufactured or semi-manufactured goods reflects this process. During the last decade, increased imports of capital goods were absorbed by different sectors of society (i.e., education, health, agriculture, communications, energy, construction, etc.), including the industrial subsystem, and—in support of the expansion of public and private research—development and implementation institutions.

Changes in the sectoral composition of production are, among others, obvious signs of structural transformation. They are generally associated with changes in demand, foreign trade and the use of factors. Regarding changes in consumption patterns, the decreasing representation of the agricultural sector in the Ecuadorian economy can be observed in the evolution of food consumption in relation to GDP. Despite household consumption being the main contributor to GDP growth between 1966 and 1994, food consumption accounted for almost half of total consumption in the 60 s but its representation reduced to 32% by 1994 (Marconi and Samaniego 1995). This transformation has involved processes of industrialization, rising tertiary sectors (services) and technological intensity, inter-sectoral and regional labor displacements and changes in income distribution. In fact, while per capita income nominally increased by 8.8 times, the share of the agricultural sector in the Ecuadorian economy decreased from 26.5% in 1966 to 11.5% in 1981 (Marconi 1985) and to 8% by 2016 (BCE 2016). This evidence of structural change has been accompanied by a trade surplus in the agricultural sector. It exported a yearly average of USD 9 billion of agricultural goods between 2012 and 2014 and imported just USD 1.3 billion. Given that demand is less than supply capacity, Ecuador may not be fully utilizing its available resources, which could be transformed into bio-products.

Ecuador's export sectors are maturing and should see organic growth in volume terms over the coming five years (Duff and Padilla 2015). In addition, based on a computable general equilibrium model, Wong and Kulmer (2011) find that the European Union-Ecuador trade agreement, which came into effect in January 2017, will likely rise real wages for skilled and unskilled workers in the rural sector. However, this may also be accompanied by falling employment among unskilled workers in urban areas. Jobs for rural unskilled wage work account for around 15% of total employment, thereby potentially reducing poverty.

During the last decades, a wide range of public agencies have implemented efforts to enhance productive activities in the rural sector (i.e., outside and within forests) through a mix of incentive-based and command-and-control conservation and productive programs. In addition to marginally promoting bio-trade of non-forest products within protected zones, the Ministry of Environment introduced Socio Bosque, a conditional payment to align landowner's incentives to protect private forests areas. On the other hand, the Ministry of Agriculture has implemented large initiatives aiming at increasing productivity in rural production. Furthermore, the strategic sectors (hydroelectric, oil and mining) have influenced the rural sector through policies promoting the change of the energy and productive matrix. The aggregated effect of these policies is an increased relative and absolute participation of the rural sector in the Ecuadorian GDP, significantly altering the tradeoffs between the contribution of the primary and industrial productive activities to GDP, labor migration, deforestation and biodiversity (Falconí and Larrea 2004).

The evidence above indicates that structural change in Ecuador has been accompanied by social, economic, political and environmental changes. Policies have directly and indirectly induced the expansion of the agricultural, hydroelectric, oil and mining frontier at the expense of forests and biodiversity.

Socio-ecological transitions in Ecuador

Falconí and Vallejo (2012) argue that key determinants that promote socio-ecological transitions in Ecuador, as well as in other Andean countries, are economic efficiency, income redistribution and physical sustainability, for extractive economies: (i) induce environmental pressures and deepen inequalities, and (ii) imply economic growth prospects limited by the ecosystem's carrying capacity.

The need to promote public policies that guarantee the environmental, social and economic sustainability of the rural sector creates an opportunity for a pattern of specialization that considers biodiversity as a strategic resource for Ecuador's sustainable industrial development. Additionally, low prices of commodities generate a crisis of alternatives in the rural sector, but also an opportunity for production schemes based on biodiversity that reduce the vulnerability to external shocks. Consequently, it can be argued that Ecuador has sufficient conditions to include bio-industry within its industrial sector. In fact, the National Strategy for Biodiversity (NaBiS) 2015–2030 has been designed to pave the way for the industrialization of biodiversity based on bio-knowledge.

Structure

We now consider the characteristics of the NaBiS 2015–2030, an institutional arrangement designed to protect biodiversity to catalyze a sustainable transition of the Ecuadorian economy (MAE 2016a). This transition is not only formally aligned to the Aichi Targets agreed upon by the Convention on Biological Diversity, but more importantly, to the country's own development approach, and seeks to overcome structural inequities and relations of dependence generated by the current primary-extractivist and export-dependent model through bio-knowledge accumulation (SENPLADES 2013). According to a recent study, its full and effective implementation requires an investment equivalent to a 0.38% of Ecuador's GDP (MAE 2016b).

On implementation, it should be noted that NaBiS 2015–2030 and its Plan of Action 2016–2021 have been built with an integrative vision of planning at different government levels (see Fig. 2) (MAE 2017). On the one hand, their targets are closely connected with the priorities established in the National Development Plan, the guidelines under the environmental sustainability axis of the National Territorial Strategy, and the strategic value-chains prioritized in the National Strategy for Changing the Productive Matrix; on the other hand, with the local demands collected in the last participatory exercise to update Zonal Planning Agendas. The challenges now lie in ensuring that decentralized governments internalize the proposals obtained from participatory processes in their local planning, and, given the cross-sectoral nature of biodiversity, in articulating with all the agendas of inter-sectoral coordination as part of a multi-level governance structure.

We explore NaBiS in the context of the National Strategy for Changing the Productive Matrix (Vicepresidencia del Ecuador 2015), which implies the strengthening of an articulated institutional arrangement between public, private

Fig. 2 Ecuador's bioeconomy institutional arrangement

and community actors that take advantage of territorial comparative advantages and —fundamentally—the economic decisions in the scientific and technological knowledge; all within a framework of environmental sustainability and respect for the rights of nature. Considering this arrangement is essential to construct a new economy based on biodiversity as its main competitive advantage, in line with the Constitutional provision that sets biodiversity as key strategic resource.

The National Strategy for Changing the Productive Matrix involves three main phases for the transformation of specialization patterns, wealth generation and income distribution (see Fig. 3). Its objective is that the relative shares of knowledge-based goods and services—including bio-knowledge—and tourism services have a greater weight in GDP than those generated by the primary sector. For this matter, the strategy has prioritized nine sectors and thirteen chains to diversify production, generate added-value and increase the exportable supply based on inputs from ecosystems and biodiversity. Nascent industries will benefit over a four-year horizon from a public investment of approximately USD 47 billion.

The most salient NaBiS attributes setting forth the development of an Ecuadorian bioeconomy are presented in Table 1. In addition to some discussed earlier, we have included attributes impacting different scopes of action.

Performance

We present three predictions regarding possible outcomes to the ruling development approach in Ecuador, interpreted as the aftermath of the NaBiS in joint performance with the institutional arrangements that informed it. The first two scenarios describe outcomes provided that no additional efforts are placed in delegating biodiversity the central role for development, the basic idea underpinning a bioeconomy model. Recent research points to critical issues arising from the implementation of Ecuador's development strategy (see Cypher and Alfaro 2016; Childs and Hearn 2017), which will likely hinder the NaBiS from reaching its set targets.

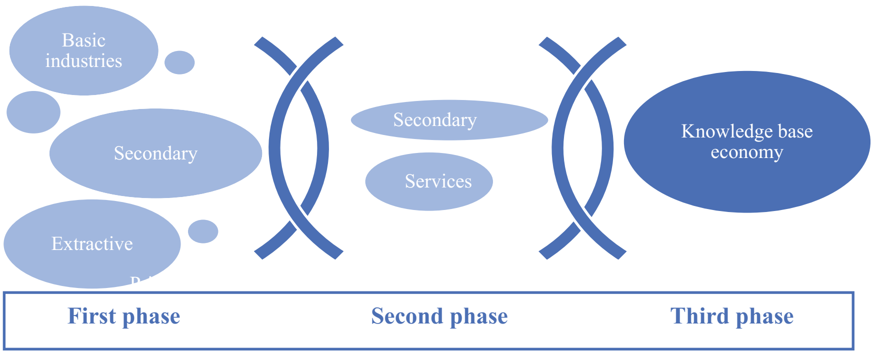

Fig. 3 Transition process underlying the National Strategy for Changing the Productive Matrix

Table 1 Identified NaBiS 2015–2030 attributes fostering bioeconomy

Scope	Description
Institutional sector	
Governance	– Includes mechanisms of **local participation** and their link with sectoral and national authorities and national planning systems – Promotes **access to ICTs** and improvement of information systems (e.g., System of Environmental and Economic Accounts) – Requires consideration of internal (scale, specialization, technological practices, etc.) and external economies (raw materials suppliers, labor force, agglomeration, etc.), thus a more **detailed planning** and **better-quality information** generation
Fiscal policy	– Promotes **coordination** of environmental public investment with selective actions for productive purposes, as well as channelling resources from the international cooperation – Aims at **mobilizing financial resources** from taxes, loans, equity investments and securities to promote rural productivity and R&D
Regulation	– Enables a conducive regulatory environment to explore **border regulation** and works on policies to **avoid merchandise flows** – **Coordinates** environmental and agricultural **incentives** with those set in the Organic Code of Production, Trade and Investment, Organic Law on Internal Tax Regime and Organic Law on Incentives for Public-Private Partnerships and Foreign Investment
Economic sector	
Real GDP	– Seeks to a) **maximize** the benefits of **exports** based on internationally competitive inputs, and b) **maximize domestic** input **production**, establishing reference prices and strategic storage stocks to achieve food sovereignty – Generates new **incentives to increase** the **productivity** and **added value** of the agricultural and livestock sector – Introduces **incentives** related to the **demand**, that foment the processes of certification or through the systems of public purchases
R&D	– Promotes basic and applied **research** to innovate and **diversify solutions and products**, improving efficiency, the implementation of best practices and incorporation of state-of-the-art technology from the use of biodiverse inputs
Local development	– Promotes the development of **physical communication** (terrestrial, fluvial, air) and availability of **communication systems** – Promotes the **anchoring of human capital in these territories**, by boosting the national bio-industry – **Anchors biodiversity to territory** through increasing local demands (i.e., gourmet food, handicrafts, bio enterprises, etc.), promoting the domestication of species for on-farm production and sustainable use in native forests
Regional development	– Plan **terrestrial connectivit**y between cities, populations and Amazonian settlements to improve territorial competitiveness, maximizing the external economies for companies and minimizing risks of deforestation – Creates a **cluster of biodiversity** to promote the development of bio-enterprises to foster regional development

(continued)

Table 1 (continued)

Scope	Description
Private sector/ entrepreneurs	– Supports programs for **small and medium size initiatives**, e.g., an incubator and trading facilities – Supports the development of **replicas of successful business models**, based on the use of biodiversity – Promotes the bio-industry with technologies that **optimize protein production** for animal/human consumption purposes – Promotes **strategic alliances** with dominant companies to integrate them into the input-product matrix to biodiversity

Status quo

First, the expected performance of the NaBiS is not likely to achieve ambitious outcomes as the current transition is set to start heavy industry without having established the bridge with the prevailing primary sector. Similar experiences in Asian countries have initially fostered great capacities to export simple and basic consumer goods, before using their already high national industrial capacities to jump into the heavy industry (Amsden 2001). In addition, basic industry shows high idle capacity worldwide, thus a likely oversupply in the market. Second, Ecuador's prioritized strategic sectors have high capital-intensive production functions and will probably incur high expected socio-environmental effects. On the one hand, these sectors' development involves imports of capital-intensive inputs, such as heavy construction, specialized machinery or creating a new endogenous machine-tool manufacturing industry. On the other hand, there is a gap in terms of investments needed for R&D and the availability of highly-trained human capacities associated to its development.

The implied challenges to rural development are evident if we consider the limited opportunities for economic stimulation (i.e., job creation, wage stabilization, investment) that this scenario offers in these locations. Just as critical, we consider the danger to biodiversity that this capital-intensive development approach might represent, for it is Ecuador's main asset and the main provider under a tropicalized bioeconomy model.

Biodiversity as a priority

If, however, efforts were allocated in prioritizing the use of biodiversity, by means of increased support and promotion of R&D projects and infrastructure that generate and accumulate bioknowledge, the scenario is much more promising. As explained by Golinelli et al. (2015), the Ecuadorian bioeconomy policy has considered alternative types of research to encourage early open collaboration oriented to knowledge generation, as well as commercial research oriented to income generation through an active exchange of knowledge, technology and materials in advanced stages. While the first is expected to reward research and discourage monopolization, the latter will likely generate exportable solutions to international markets and include not only physical resources but also genetic, genomic and metagenomic information, models, methods and protocols. These opportunities may be further promoted by an increased attractiveness for international investors searching for projects or settings related to biodiversity. Current institutional arrangement (i.e., Environmental and Science and Technology Codes) is key to continue promoting bio-prospection for applied research projects, as well as throughout the strategic stages during R&D. It also incorporates opportunities for a collective license model addressing the shortcomings of the patent model (Safrin 2004; Kloppenburg 2014). Furthermore, total factor productivity might rise if micro, small, and medium-sized enterprises increasingly participate in an environment favorable to innovation rather than one paralyzed by monopolies, oligopolies, or private oligopsonies (Vivarelli 2014).

The expected consequent increase of employment and labor wages (agricultural and non-agricultural) in the rural sector might be the tip of the iceberg regarding the tangible benefits of a knowledge-based, conservation-oriented and sustainable development approach. The establishment of bio-industrial clusters strategically located near rural areas and along geographical borders not only tackles the concerns regarding lack of jobs and income instability in the sector, but will likely revitalize local consumption (endogenous economic impulse) and even call for foreign actors' attention (private or sovereign) to invest. Such strategy is not unknown to the region. Large national firms in Brazil opted for a transition through technical change, as a result of multinationals' behavior (Cassiolato and Schmitz 2002).

4 Discussion

Like any other development strategy, bioeconomy is a long term prospect. The aforementioned potential effects of strengthening bioeconomy (increased productivity, improved job generation and increased wages) should be interpreted with caution, for the bioindustry's productivity might lower at the time of policy implementation until the system's dynamics, supported by distribution infrastructure investments, produce tangible results. When such sustainable transition occurs, bioeconomy has the potential for affecting regional trade patterns (i.e., Andean region) and transforming Ecuador into a consumer of raw materials from biodiversity to add value, substitute oil-based imports and ultimately export surplus bio-products. Import substitution is especially relevant in Ecuador due to its limited monetary policy (dollarization) and vulnerability to dollars fleeing the economy.

By boosting bioeconomy, the probable increase of consumption levels within individuals in the rural sector may happen as a result of bio-products' reasonable prices. More importantly, however, sustainable bioeconomy assumes that, in the long-term, aggregated consumption may not change but its composition will be significantly altered by changing productive systems and increasing consciousness on consumption. In this sense, public procurement of bio-products can play a critical role to accelerate the transition by linking primary and secondary bio-industry through increasing demand of basic commercial bio-products.

By diverting consumption towards the bio-industry sectors and providing job stability in the rural sector, an increase of R&D investments may impact the aggregate demand, leading to increased output, despite having no effect on the individual's overall consumption level. We also note that these investments can not only reduce rural-urban migration, but also reduce the deflationary pressure in the non-rural labor market in the same way that bio-industry shows labor absorption capacity and a potential positive effect on aggregate wages in the rural sector.

Experiences in globalization of local industrial R&D of niche-based firms from developing countries indicate that high-technological competences can help local actors of bio-industry value chains become part of global R&D networks. Offshoring R&D and industrial activities to megabiodiverse developing countries of nascent stage companies in developed countries should become a regular phenomenon. This could additionally provide opportunities for local and foreign affiliates to work synergistically along de supply chain.

Our analysis also highlights the critical importance of added-value in bio-industry value chains. Considering that the share of food in expenditure falls as income rises, bioindustry should render highly added-value products to ensure those historically excluded groups the access to wealth creation productive factors (i.e., bio-knowledge and entrepreneur opportunities). In fact, we believe that bioeconomy meets sustainable development as rural sector productivity increases in tropical megabiodiverse countries, because as biodiversity assumes its central role in the economy, it contributes to conservation by satisfying poverty needs (e.g., food security) and promoting workers' transition into sustainable practices (e.g., small farming) and industries.

It is beyond the scope of this chapter to work out the aggregate implications of these several competing effects without more assumptions and a fully-specified structural model. Future research should aim to provide empirical evidence of macroeconomics effects of the Ecuadorian bioeconomy as a useful case study to derive further lessons. It is nonetheless useful to consider that bioindustry has potential to absorb the rural sector surplus labor in a demand-constrained economy.

There is a large literature suggesting that exposure to markets and new technologies affects social relations and can erode traditional forms of social protection (Scott 1985; Polanyi 1944; Marx 1847). Li (2009) notes the tension between inequality in access to land for the poor and the promotion of modernization in agricultural production. These works call for policy consideration to ensure equitable access to new wealth creation and productive factors during development of bio-industry value chains, and an overall inclusive and rights-based transition to bioeconomy.

Despite its alignment to the Strategy for Changing the Productive Matrix, further emphasis should be given to biodiversity as a key central resource in initial stages, especially to overcome current challenges (Fig. 1). We argue that bioeconomy offers greater cost-benefit advantages as the investments required will make use of increasing primary sector productivity and a blooming development of high added-value chains with less foreseeable negative social and environmental externalities relative to basic and intermediate industries. In this context, bioeconomy may offer a sustainable option for a socioecological transition. In fact, given the current economic situation, there can be expected significant larger gains in wealth generation, employment and inequalities reduction from accelerating development phases by promoting simple and basic consumer goods derive from bio-industry value chains.

5 Conclusions

Our analysis indicates that sustainable bioeconomy is being revised in Ecuador. Due to complex social and economic interdependencies, the development of the bioindustry requires tropicalizing foreign models and technologies as well as policies that support and encourage the development of value chains. The Ecuadorian NaBiS is an institutional arrangement that provides initial lessons to tropical megadiverse countries, for it has a promising role to enable a more efficient and integrated use of biological resources towards a sustainable and resilient economy, while addressing structural development and biodiversity protection challenges.

The economic potential for bioeconomy is observed to, with the appropriate investment in distribution infrastructure and increase in rural productivity, affect fossil fuel-based imports and reduce inequalities in the rural sector. To take advantage of the potential of Ecuador's bio-industry, there is a clear need to strengthen up the central role of biodiversity in the change of the productive matrix. This can be achieved by developing value chains with a structured and defined strategic vision—nourished by R&D efforts—that coordinates suppliers, producers and users in a way that is consistent with the institutional framework.

Finally, this analysis observes that the development of bioindustry in Ecuador should occur similarly to that of other intermediate and final industries included in the National Strategy to Changing the Productive Matrix. Bioindustry is likely to induce growth for the local industry adding further value into current primary production activities. The creation of a domestic market in this sector occurs more slowly, because, unlike international markets, the initial phase of a bioindustry is characterized by strong public leverage and national consumption. For this to occur, a communication strategy is recommended to increase awareness about the bioindustry's importance within a context of change of the production matrix and its long-term feasibility. Given the current strong focus on developing basic industries as a first step to start the economic transition, it seems relevant to reassess biodiversity and its role in industry impact (i.e., employment, balance of payments, public and private financial inflows). Future research should aim to develop a structural model to explore the potential for bioeconomy in a dynamic and multi-temporal context.

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