CAN DEVELOPING COUNTRIES ATTEMPT A SUSTAINABLE ECONOMIC AND ECOLOGICAL DEVELOPMENT? CASE OF TUNISIA

Sonia Ben Slimane
Novancia Business School,
Paris, France
email: sbenslimane@novancia.fr

and

Jerry Courvisanos
Federation Business School, Mt. Helen Campus,
Federation University Australia
Ballarat, Victoria, Australia
email: j.courvisanos@federation.edu.au

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Abstract

The question of growth in developing countries has become critical since the Arab Spring. The literature related to the developing countries is widely interested to the technological transfer since the wave of Foreign Direct Investment (FDI)'s benefits promised by the international institutions to the developing countries in terms of reducing the technological gaps with the expectation of social and economic development. For the Arab case, Tunisia is considered one of the most efficient, and thus attractive, countries for FDI since it is characterized by its economic reforms, liberalization of trade, financial incentives and the privatization process. In this field, just a few empirical studies have shown the effects of the FDI on the innovation and thus the economic growth of developing countries. This paper attempts to address this in the context of sustainable development.

Thus the question is how to build a new economic model of innovation to support and enhance the development of sustainable sectors while responding to the social and economic constrains mentioned above? Thus the development of new investment strategy in the sustainable development domain raises the question about new behavior in terms of public policies, in terms of investment and in terms of practices to implement scientific and ecological innovation. This requires an alternative theoretical approach with an accompanying empirically based innovation strategy.

Topic Field: Industrial policies and transition

JEL Classification: F63, O33, Q55

Keywords: eco-innovation, transition phase, paradigm shift, innovation systems

1. Introduction

The question of maintaining the trajectory of robust economic development for developing countries has become critical since the aftermath of the Arab Spring uprisings of early 2011. The economic development literature is widely interested in technological transfer since the late 1980s' wave of Foreign Direct Investment (FDI) with its benefits promised by the international institutions in terms of reducing technological gaps with the expectation of social and economic progress (Bouoiyour et al., 2008; Ozturk, 2007; Bouoiyour, 2004; Peri and Urban, 2004; Blomström et al., 2001; Bertschek, 1995; Blomström and Wolff, 1994). In this field, just a few empirical studies have shown the effects of FDI on innovation and thus economic development (Farkas, 2012; Li and Lui, 2005; Blomström et al., 1994; Haddad and Harrison, 1993). For the Arab case, Tunisia is considered one of the most efficient, and thus attractive, countries for FDI since it is characterized by its economic reforms, liberalization of trade, financial incentives and the privatization process (UNCTAD, 2004). Tunisia was also the nation where the Arab Spring began with the self-immolation of Mohamed Bouazizi on 17 December, 2010.

Since the Arab Spring, two constraints to economic development have emerged. The first is social. This is related to the need for a new strategy supported by the populous in response to the high level of unemployment. The second is economic. This is derived from the decrease of FDI due to rising uncertainty with continued high unemployment. Together these two constraints severely limit the ability for innovation to prosper. The post-uprising period cannot be analyzed with a standard neoliberal economic growth model of innovation that has failed in a dynamic perspective (Sadik and Bolbol, 2001; Aitken and Harrison, 1999) and does not lead to technological catch-up in the innovation race (Courvisanos, 2012, p. 227). Moreover, the question of building new models of innovation-based on sustainability is becoming critical to these countries since it takes into account social and long-term aspects. Some authors consider that innovation does not lead to a better quality of life which is related to the sustainable development. This is because innovation is seen by these authors as a source of unsustainable economic growth with degradation of environment, mostly due to technology-push (Kalaora, 2005; Zawislak and Marins, 2007). On the other hand, the concept of sustainable development as defined by the Brundtland Commission is an essential innovation development tool that "…meets the needs of the present without compromising the ability of future generations to meet their own needs." (WCED, 1987, p. 8) This Brundtland approach contains within it the capacity for ecologically-based innovation to overcome the two constraints of social and economic development. This integration if applied in the case of the Arab Spring countries can potentially reconcile the social and economic constraints. For the case of Tunisia, this is an important starting point to build a new model of innovation; one which is considered in this paper.

The choice of the case of Tunisia is motivated by the political and social revolution of the Arab Spring uprising itself in a country that by African standards is highly educated and economically efficient, as well as the instability during three years following the uprising. Consequently, the main question which arises is related to the economic model to be adopted in the future with regards to economic and social situations that have suffered from political instability. The question of the eco-sustainable model of innovation is also motived by local endeavor in past five years in important sectors such as the energy and the water. These sectors yearn for new forms of innovation and the adoption of new technologies.

Thus, the question is how to build a viable economic model of innovation to support and enhance the development of sustainable sectors while responding to the social and economic constraints mentioned above? Economic development needs to embrace ecologically sustainable innovation for the future by taking the regional opportunities and addressing local constraints that are specified. This question is fundamental since the three pillars of sustainable development are social, economic and ecological. Thus, the development of new investment strategies in the sustainable development domain raise the question about new behavior in terms of public policies, financial support and innovation practices (both scientific and ecological) can be implemented. This requires an alternative theoretical approach with an accompanying empirically-based innovation strategy.

2. Literature Review: Alternative Innovation Models

Any alternative economic development model that is dynamic and based on innovation must begin with Schumpeter (1942) in which innovation through creative destruction provides a structural change path away from recent crises, and sets up technological and economic regimes that are long-term sustainable. Given the current financial, economic and ecological crises, standard innovation models derived from neoclassical economics are inadequate as they have not overcome the various lock-in mechanisms that dictate the paths of innovation which contributed to the current set of crises (Courvisanos, 2012). It is impossible to achieve the required paradigm (or regime) shift to sustainable development in innovation under conditions that have created the existing "lock-ins" (Kemp et al., 1998), or what Barker (1993) calls "paradigm effects".

From a Schumpeterian perspective, innovation has a technological driver component that leads to tangible investment which creates capital accumulation that leads to an identified secular economic growth path (Verspagen, 1993). Thus, technological innovation is the commercial implementation through tangible investment of new technical knowledge. This knowledge is derived from intangible investment in scientific or engineering developments on specific Research and Development (R&D) activities or in the course of day-to-day production and marketing activity (Sahal, 1981, p. 42). The chain of innovative activities ranges from epoch-making major new technological innovations (like the microcomputer chip) to minor marketing-based product innovations (like modifying a car model by adding fins to its rear).

For Schumpeter (1939), the entrepreneur responds to waves of optimism and pessimism to create clusters of inventions, which then are diffused through the bunching of physical investment: the "clust-bun" effect (Courvisanos and Verspagen, 2002). This leads to investment cycle patterns and the development of a trigger mechanism to significantly increase the rate of investment in incremental innovation by the established large corporation on the basis of a specific basic (or radical) innovation already created leading to an economic upturn. At the bottom of the investment cycle there is a need for an innovative trigger to shift the economy out of crisis with a severe "vicious circle" effect. The innovation trigger initiates a "virtuous circle" effect which results in investment rising as basic innovations are being diffused. This increases the amplitude of the expansion phase of the investment cycle, raising innovation intensity and shifting the economic trend trajectory upward (Toivanen et al., 1999).

There are two problems that arise with this Schumpeterian explanation. First, the political conservative Schumpeter sees no active role for demand or any public policy demand stimulus in the upturn from cyclical troughs (Medearis, 1997). Despite public demand stimuli by Germany's war preparations and USA's New Deal in the 1930s, Schumpeter (1939) places active stimulus purely on the innovation supply-side "impulse". Rothbarth (1942), in his review of Schumpeter (1939), identifies that this supply-side impulse also needs a Keynesian 'adaptation mechanism' of funding for investment. However, the need for profits to fund investment in a very uncertain and depressed economic environment is a major stumbling block to the innovation path. From a Keynesian effective demand perspective, entrepreneurs make their investment decisions into innovation in the short period. This perspective comes from John Maynard Keynes's contemporary Post-Keynesian pioneer Michał Kalecki (Harcourt, 2006, pp. 160-4), in which the long-run economic growth path is "…a slowly changing component of a chain of short period situations" (Kalecki, [1968] 1991, p. 435). Kalecki regards short period innovation promotion as crucial, arguing that the "...influence of this factor is analogous to that of an increase in aggregate profits which in the course of a given period makes investment projects generally more attractive than they were at the beginning of this period." (Kalecki, [1954] 1991, p. 334) Through this process of innovation, together with innovation-induced profits (or other financial instruments), a dynamic secular growth path is generated. Thus this path, permitted by innovation which generates profits through investment in innovation, is the short period effective demand sequence which allows further innovation and investment in the next period.

The second problem is the source of the innovation impulse as outlined by Schumpeter himself (Schumpeter, 1942). Dominant firms are so significant to national economies that governments need to support them, resulting in a State-supported mendicant capitalism. Schumpeter's apocalyptic vision has echoes in the Global Financial Crisis (GFC) of late 2008 with companies like General Motors no longer able to effectively innovate and compete (Wells, 2010). Neo-Schumpeterians have addressed this second problem by recognizing that the market fails and interventionist innovation policies need to be both active and positive in the direction of encouraging variety, fostering experimental behavior, supporting new developments, focusing on system building, enhancing diffusion, promoting learning organizations and their skills training, as well as assisting to influence expectations through broad-based grants, tax concessions, mentoring, and supporting small business services (Witt, 2006). Many examples of success in this interventionist innovation approach can be noted: war-based economies, reconstruction from major devastation (e.g. the Marshall Plan), national sports-based academies, regional clustering around universities and technology parks (Smith, 1998).

The lack of an aggregate demand element in neo-Schumpeterian economics has been long recognized, but only limited research has been conducted in this area. Freeman and Perez (1988) made a tentative attempt to integrate the neo-Schumpeterian perspective of paradigm shift with Keynesian demand accumulation, but not much has been developed since. To this 1988 model, Perez (2002) has made further significant supply-side refinements using historically related periods called "installation" and "deployment". This model begins with invention and the early attempts at installing the new innovation with financial entrepreneurs who are prepared to support R&D in a highly uncertain situation. Perez (2002) then explains how deployment of technological systems and paradigm shift arise only after all the minor improvements (endogenous innovation) are squeezed out of the old systems and paradigms by "monopoly capital" entrepreneurs who want to protect existing capital stock and delay the new paradigm taking over. There is also "log jam" in endogenous innovations based on the new paradigm which compounds the latter's slow initial adoption. This occurs when established powerful capitalists, with much old capital stock, cannot justify the entire shake-up of industries, since not enough interrelated clusters have been formed. In some way (*via* collapse of speculative bubbles or insufficient effective demand), recessions send the old capitalists to the Marxian "dustbin" of history. New capitalists' reactions against uncertainty of profits come from competitive pressures and growing inefficiencies of old capital stock. This induces adaptation, deployment and diffusion of innovation, creating a new technological trajectory, establishing a strong investment upturn. At the same time this upturn re-establishes the conditions for a new phase of steady development. A paradigm shift occurs when the new adapted technological systems pervade the whole economy. This is a very sophisticated path to renewal, but it lacks a political economy perspective with effective demand remaining in the background and the lack of a social democratic role for the State (Jessop 1993).

For all the potency of the neo-Schumpeterian innovation path identified above, there is a strong supply-side element to the innovation drivers. Market demand fails to register, leading to the problem of effective demand and how this limits any innovation path. From this emerges the most critical factor; the lack of market power as a crucial element in the innovation process, despite the occasional reference to market concentration strength as a negative influence on innovation. It is to these elements of effective demand and market power, combined with elements from the neo-Schumpeterian models, that a conceptual framework is developed below which generates an economic and ecological sustainable innovation path.

3. Conceptual Framework

Paradigm shift of a development path only succeeds if the specifics of an eco-sustainable framework can be clearly enunciated and its vision seen to be practically achievable. This requires the synthesis of ecological and economic objectives so that profits are, through continual regressive inference (or iterative feedback), effectively and proactively invested in innovation that transforms society *via* an ecologically sustainable development path. The process requires co-evolution by the private and public sectors. An overall investment planning strategy is the essential adaptation mechanism that allows for eco-innovation to flourish. Three criteria sets up this framework, as detailed in Courvisanos (2005): (i) sustainable ecological rules (or conventions) with specific ecologically-based targets, e.g. temperature rises under 2 degrees and 350 parts per million carbon dioxide emissions, (ii) perspective planning that is readjusted as the development process moves through time with clearer perspective and less uncertainty, and (iii) cumulative effective demand built on creating stronger market demand though transition management from niche markets to critical mass. What is required to implement this framework is a broad-based strategy for public and private organizations and institutions towards a dual ecology/economic outcome. Then, if successful at the nascent level, cumulative causation with much less crises-prone economic activity can lead the country to enhance ecological outcomes over time.

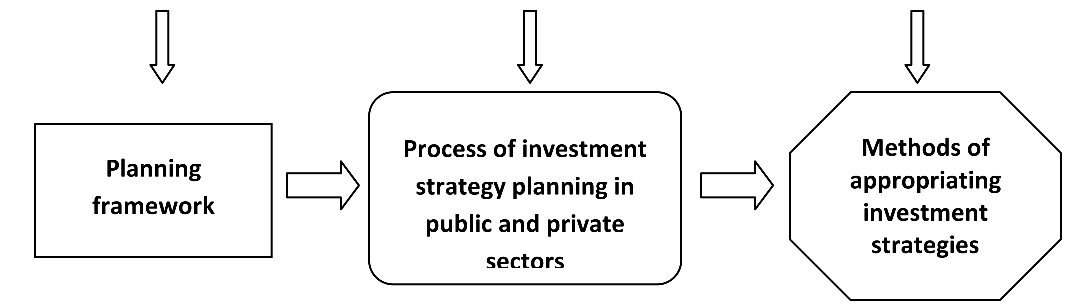
The eco-sustainable framework set out in this section provides a comprehensive approach to how an investment strategy can be introduced into an economy like Tunisia, in order to achieve the stipulated goal of an innovative, competitive and ecologically sustainable environment. Only a few Western European countries, notably The Netherlands and Denmark, have been prepared to go down this path of an "instrumental planning" process (Lowe, 1976) with public programs such as national strategic environment plan, short-term targets and target groups, private sector cooperation, voluntary conformity, and citizens' group input. Such a plan needs to be backed by the threat of regulation and withdrawal of support policies like subsidies (see Wallace 1995, pp. 43-61). Crucially missing from this

European plans experience is the ability to promote innovation through technological succession, which is where investment planning in concert with a co-evolutionary strategy between public and private sector can provide the necessary link to new sustainable technologies. This co-evolution strategy of technologies and industry structures requires a strong link between the techno-economic and political systems as they evolve in instrumental plans with private practice and public policy together.

Figure 1 sets out the eco-sustainable framework that aims to deliver such instrumental plans with the operational aspects in the grid **(**on the top), and the investment planning process in the flow-chart (below). The left column has the three pillars (or elements) of the eco-sustainable planning framework. The centre column sets out the criteria for sustainable development required in both public and private sector investment planning within the specific country's institutional and cultural domains. The right column shows specific implementation strategies for innovation that support the investment plan. The bottom row is a flow-chart which indicates how one column should interact with the next in the planning process. The flow-chart is a practical procedure for a coherent planning process with a cohesive framework for investment that allows specific strategies to induce eco-innovation. Supporting implementation strategies operate as separate entities in different places around world. In the application of this framework to Tunisia, such strategies are discussed in detail of Section 5 below.

Figure 1: The eco-sustainable framework

Eco-sustainable Framework	**Investment planning criteria**	**Supporting implementation strategies**
Ecological rules	• Sustainable long-term carrying capacities • Resource-saving new capital stock	Develop and communicate appropriate sustainability rules
Perspective planning	• Iterative flexible *ex-ante* planning • Bottom-up monitoring and evaluation	Establish, monitor, evaluate and adapt environmental policies
Cumulative effective demand	• Strong niche market base • Experience from current eco-sustainable innovation-based users	Co-evolution techniques to developing and managing sustainable user-needs



4. Methodology

To explore the possibility of building technological regime shift in the transition phase of developing economies, Tunisia is used as the case study. It has the knowledge base (e.g. level of education) and institutional infrastructure (e.g. R&D/innovation system) to make paradigm shift possible. Following the theoretical construct based on the conceptual framework above, empirical research is conducted on existing public policies supporting innovation and private sector innovation capacity. Exploration is conducted through, secondary data (from the UNCTAD, 2013) and local data from institutions supporting scientific research and technological innovation, and economic support for investment. Using these data sources, an evaluation is conducted on common parameters and test current innovation policies in Tunisia for sustainable development. The results would assist in evaluating the current efforts in Tunisia and thus to propose adapted tools to support a regime change of the national system of innovation in Tunisia based on sustainable and ecological development.

5. Case Study: Tunisia in Context

This case study is conducted on Tunisia to demonstrate the effects of including the environmental concerns in economic activities since the sustainable development paradigm had taken root in the country. From this analysis of Tunisian policies, key proposal can be formulated to ensure that in long run continued economic growth can also be ecologically sustainable.

Tunisia is characterized by three main initial features that are specific. The *first* feature concerns the performance of the country in term of growth. Tunisia is considered as one of "the leading performers" in the group of emerging economies with a sustainable 5% growth rate/year between 1995 and 2010 (World Bank, 2010). In 2007, among the MENA (Middle East and North Africa) group of countries, Tunisia's GDP/capita (in constant USD) was higher than that of Egypt (3.1%) and Morocco (2.1%). This performance is explained by the engagement of the Tunisian Government in structural reforms since the mid-1980s that have been managed to ensure the development of the country. The reform centers on: maintaining macroeconomic stability in the face of external shocks, improving the business climate to attract FDI (Foreign Direct Investment), diversifying the education system, gradually opening up the economy, and deepening its integration with Europe following trade agreement signings in 1995.

The *second* characteristic is the engagement of the country in the integration of environmental issues into economic growth since the mid-1990s. Indeed, Tunisia "…has a solid record of environmental and resource management and effective use has been made of limited endowments of land, water and energy resources" (World Bank report, 2010). In concrete terms, the following policies have been implemented:

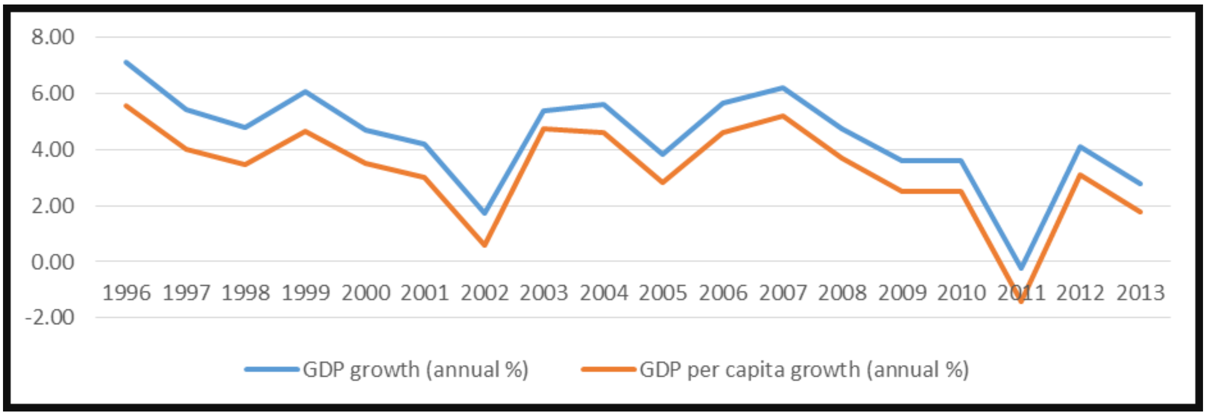
- Promotion of energy efficiency and renewable energy, which has contributed to an energy intensity of 0.08 ktoe per US$1000 of GDP. However, this is well below the MENA average of 0.18 and even below the world average of 0.13, which implies that a further 10% gain in energy efficiency would raise GDP by 0.4%, suggesting that many investments would be cost effective (World Bank report, 2010).
- Urban water is supplied 24 hours a day and coverage is universal, while water saving technology in the agriculture sector has increased water use efficiency to the second highest in the region. Nevertheless, renewable water resources/capital use is less than half the MENA average.

- Population density is relatively high, especially in some parts of the coast, yet the cost of air pollution was the lowest of eight MENA countries covered in a World Bank study (Sarraf, 2004).

However, some resource constrains mainly in water and land, remain. Consequently, a strong policy framework is needed that reflects the economic value of resources and more integration of sustainable development issue.

The *third* reason is related to the “Jasmin” revolution, which has identified the unemployment problem, especially that for higher educated graduates (20%). This unemployment shows the fragility of economic growth in Tunisia and is evident in Figure 1 which shows that since 1996 Tunisia has more sustained rather than improved its long term economic performance. Consequently, solving the employment problem and improving the long run economic growth depends on Tunisia’s success in moving to a different growth model, driven by innovation. An innovation-driven growth model should include more investment in innovation in new sectors that include the environment issues and sustainable development.

Figure 2: Tunisia – Annual GDP growth 1996-2013



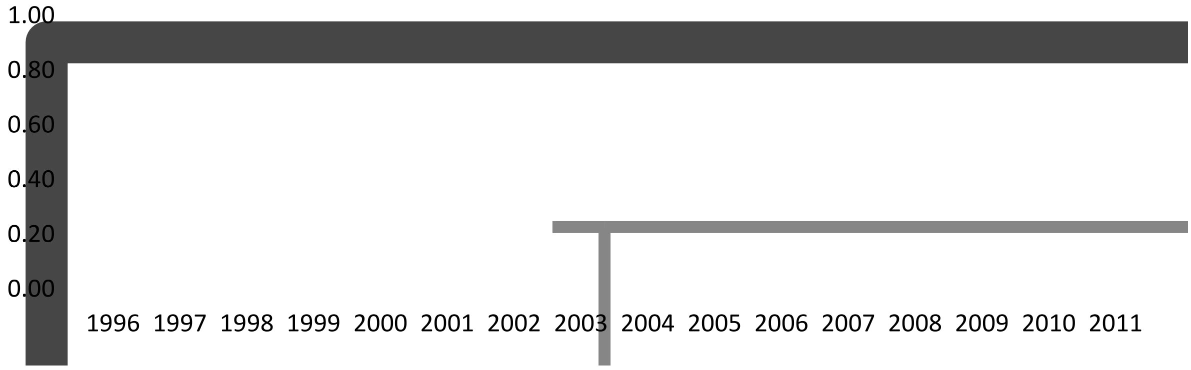
6. Sustainable Development in Tunisia

The sustainable development (SD) policies introduced in Tunisia are set out in this section, based around two major policy tools; (a) national energy agency and (b) national development policy.

a. National Agency for Improving Energy (ANME)

The creation of the ANME program in 1985 aimed to focus efforts on research, and on providing incentives and technical demonstrations and building public awareness. The effectiveness of the ANME efforts started in 2005 with the establishment of Energy Services Companies (ESCOs) to provide integrated project management and the National Fund for Energy Conservation (FNME) which facilitated financing investments in energy saving. The graphic below (graph.2) confirm this effort as we note the national efforts to use renewable energy to produce electricity.

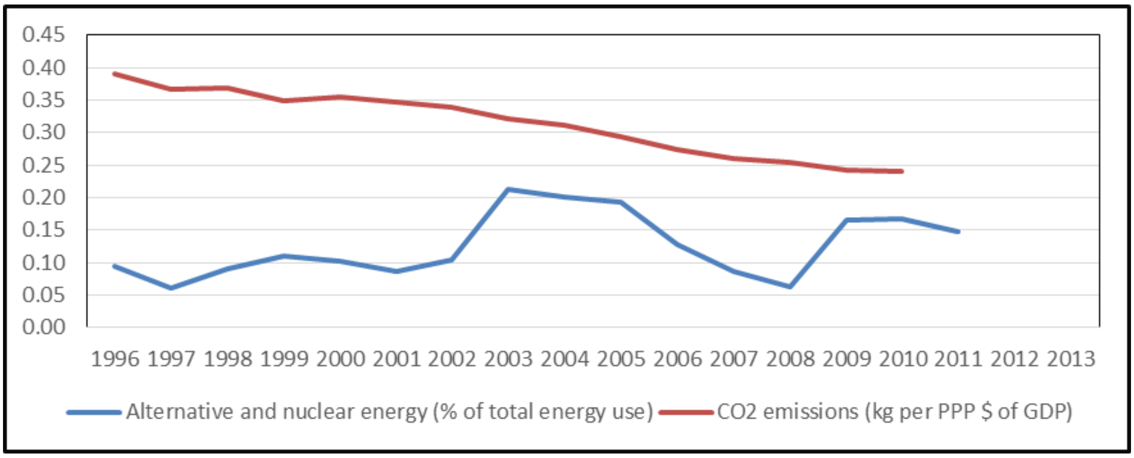
Figure 3: Tunisia – Renewable electricity production (excl. hydro) 1999-2011



Note: Electricity production from renewable sources, excluding hydroelectric, as a percentage of total electricity production

Note also the effects of using renewable energy on the environment with the decrease of the CO2 emissions at the same period see Figure 4.

Figure 4: Tunisia – Alternative/nuclear energy use and CO2 emissions 1996-2011



Despite the effort made to promote renewable energy, electricity from gas remains the main source of electricity production, see Table 1.

b. *11th Development Plan (2007-2011) and environmental issues*

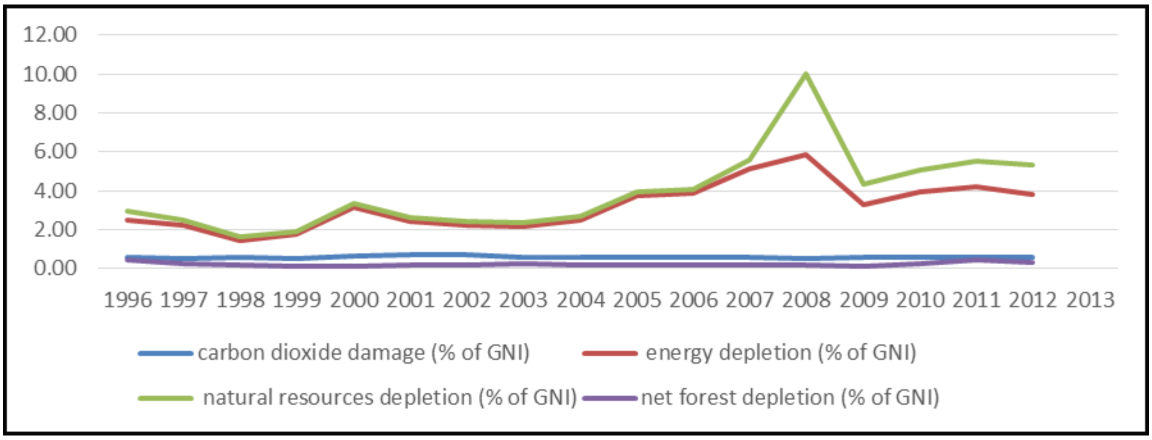
The second public policy is related to the integration in the national 11th Development Plan (2007-2011) of environmental issues, in a perspective of SD. In this national plan, the objective was to reduce energy intensity by 2-3% annually and increasing the use of renewable by 4% through greater emphasis on investments in energy efficiency and renewable.

Table 1: Tunisia - Energy consumption: Fossil, Alternative and Renewables 1996-2011

year	Fossil fuel energy consumption (% of total)	Alternative and nuclear energy (% of total)	Combustible renewables (% of total)
1996	86,92	0,09	12,97
1997	86,77	0,06	13,16
1998	87,32	0,09	12,61
1999	87,17	0,11	12,72
2000	87,12	0,10	12,78
2001	87,32	0,09	12,58
2002	87,07	0,10	12,89
2003	86,81	0,21	13,00
2004	87,04	0,20	12,78
2005	86,32	0,19	13,49
2006	86,59	0,13	13,28
2007	86,59	0,09	13,33
2008	86,70	0,06	13,24
2009	85,45	0,16	14,35
2010	85,42	0,17	14,40
2011	85,25	0,15	14,63

As a consequence, a 4 year energy management program (2008-11) was initiated, including sustainable development concerns into economic growth. The aim is to sustain economic growth through the substantial application of appropriate development models that take into account the country's natural resources conservation. Figure 5 shows the trend of depletion of natural resources which reinforces the necessity of integrating the environmental issues in the economic strategy.

Figure 5: Trends on Tunisian energy and natural resource depletion 1996-2012



Thus, the plan aims to orient the traditional economic sectors (agriculture, industry, extractive activities, tourism and transport) towards management modes that preserve nature and production ecosystems, as well as promote production systems that are ecologically rational and economically viable. Figure 4 shows the national effort in reducing CO2 emissions since 1996.

The Economic Commission for Africa (ECA, 2011) has conducted a program in order to evaluate the position of the African countries (16 selected countries) with regards to SD issues. According to this program, Tunisia is one of only two countries that have implemented the National Environment and Sustainable Development Program (NSSD) since 2002 (Algeria is the only other one). The NSSD was identified as the priority action for implementation within the framework of the 9th National Plan, which consisted of:

- Development of regional programs on environment for SD, based on regional indicators for promoting sustainable companies (industrial, tourism, agriculture);
- Integration of environmental concerns into economic development activities; and
- Maintenance of ecosystem integrity.

7. Analysis of Sustainable Development in Tunisia

Two steps are conducted in this analysis; first univariate and then bivariate analysis. The aim is to evaluate the effectiveness of Tunisia's SD policies as set out above.

The first step is to examine SD policies by using descriptive time series data for the period 1996-2012. The data used include more than 1,000 economic, social, environmental indicators for Tunisia. There are limitations to the data collected from the world competitiveness Forum (2013):

- Some key indicators are not available for long periods, such as private investment in energy, investment in infrastructure, investment in renewable energy.
- Key indicators related to innovation effort in SD not available (e.g. investments to sustainable sectors, sectors efforts, investment in energy, R&D)

Ten indicators are obtained that are most significant. These indicators are tested for correlation between innovation efforts and alternative energy use from one side and the realization of sustainable effects, which can summarized as a schema in Figure 7.

The univariate analysis conducted is by the four individual groups of indicators, based on the Figure 7 schema. Figure 6 looks at the two SD indicators of (i) particle emission damage (PartEmDam) as a percentage of Gross National Income (GNI), and (ii) CO2 emissions as kilogram per US$ (purchase price parity, PPP) of Gross Domestic Product (GDP).

Figure 6: Univariate Analysis of Tunisian Sustainable Development 1996-2012

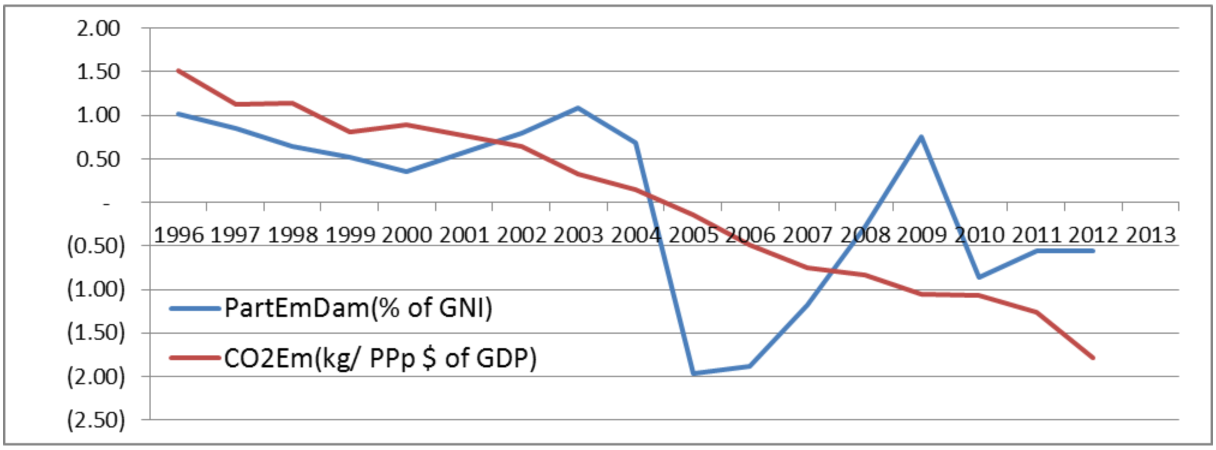
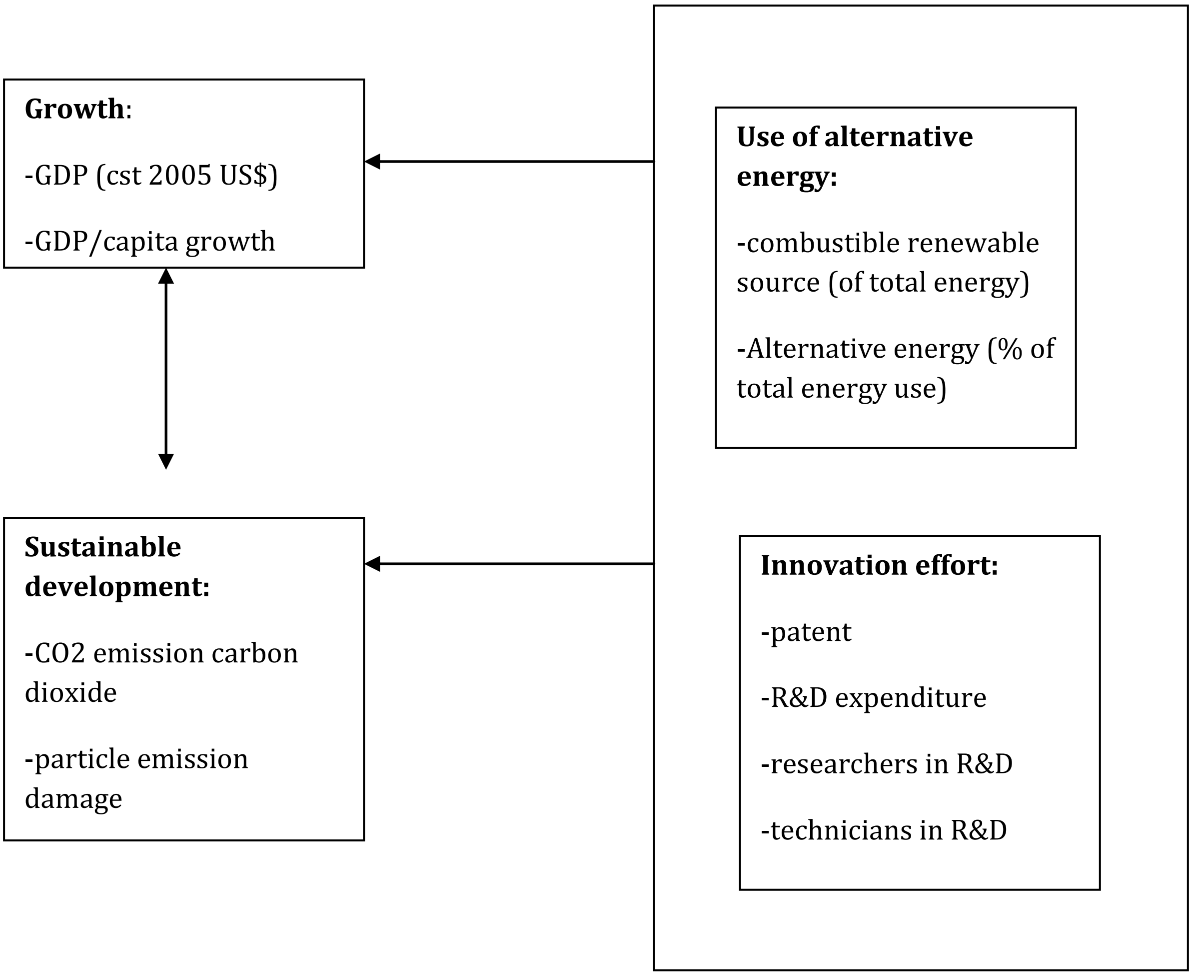


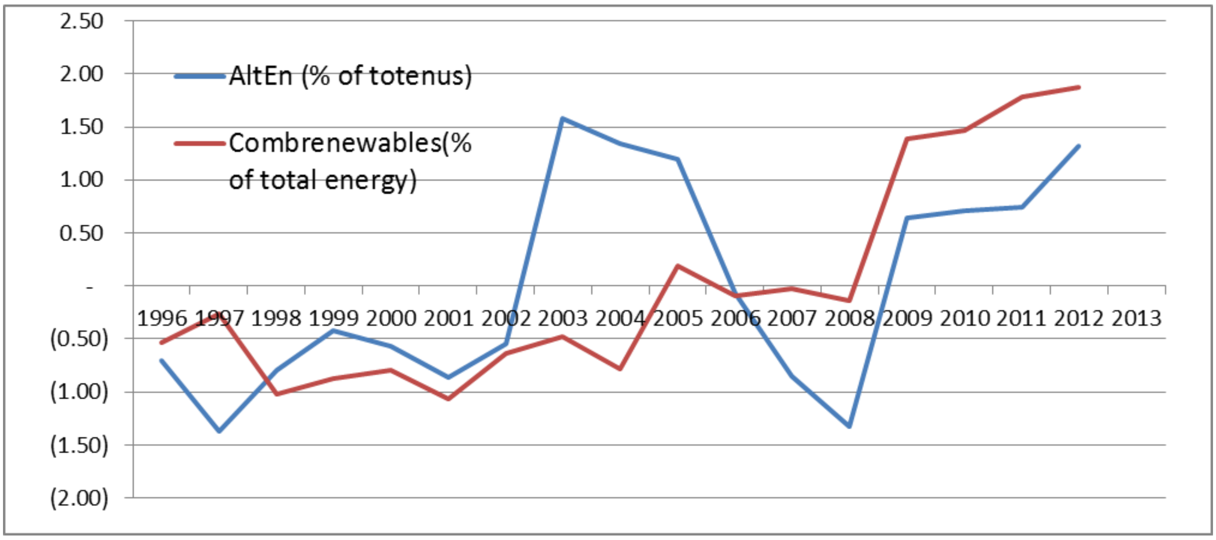
Figure 7: Schema of Analysis of Trends in Tunisian Sustainable Development



The results from Figure 6 show the fluctuation of the indicator group "particle emission damage" during the period is significant. Consequently, the CO_2 emission (Kg/PPP of GDP) variable for sustainable development is retained as the indicator.

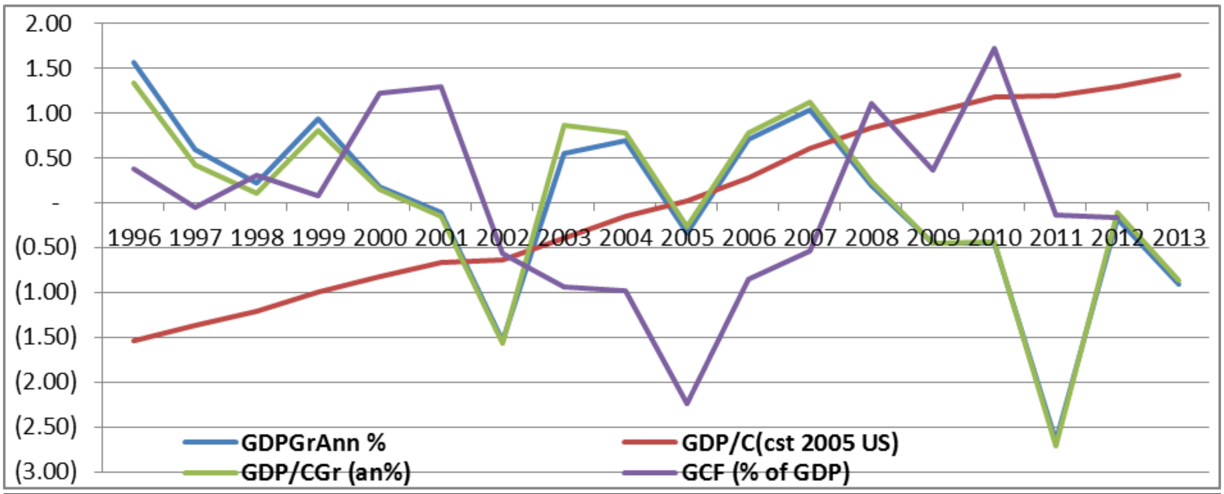
Then, analysis for energy efforts (realizations) variable is carried out. A test for significance of the indicators shows significance with the use of alternative energy (% total energy use) and combustible renewable (% of total energy). The results are shown in Figure 8.

Figure 8: Energy Efforts Variables 1996-2012



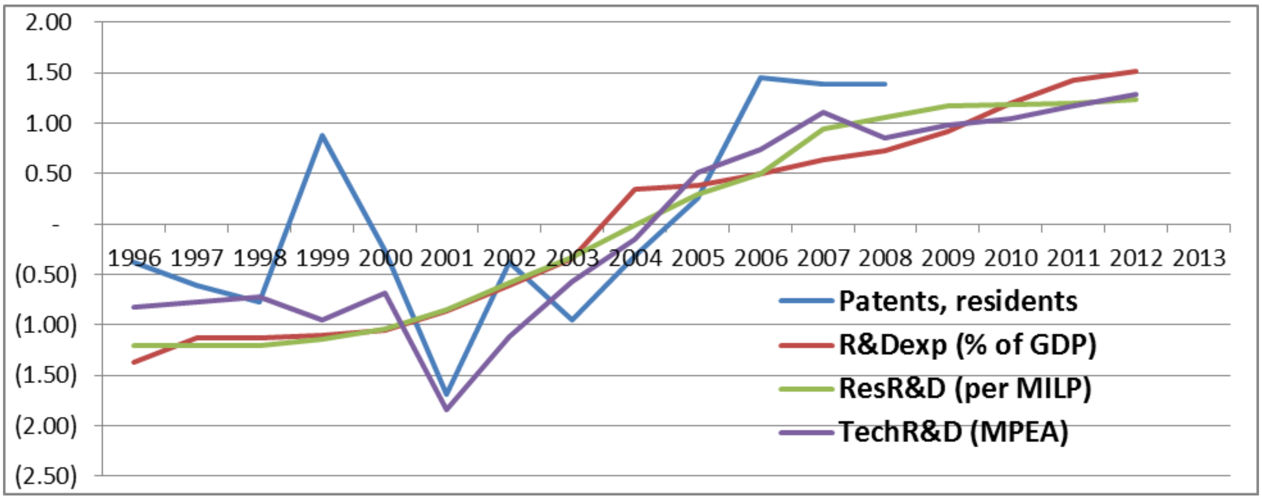
The same analysis is made for the growth variable and the results show the significance of the indicator GDP/capital (constant 2005 US) as shown in Figure 9.

Figure 9: Growth Variables 1996-2012



Finally, test for significance of the indicators related to innovation efforts is conducted. The univariate analysis results show the significance of the R&D expenditure (% GDP) and the R&D researchers (per million people) as shown in Figure 10.

Figure 10: Innovation Effort by Various R&D Measures 1996-2012



The second step consisted on conducting a bivariate analysis by taking into account the retained variables: CO2emission (kg/PPP of GDP), the combustible renewable (% of total energy), GDP per capital (cst 2005 US) and the R&D expenditure (% of GDP). The results show that all the variable have the same trend over the period (1996-2011), except the CO2 emission which could be interpreted by the fact that as the efforts on energy made, they have a positive effect on economic growth and on reducing the CO2 emission. This confirms that the related issue of SD should be reinforced through R&D expenditure, integrating the energy efficiency in the economic strategy. This would then improve the situation as it has a positive effect on economic growth and on reducing CO2 damage on environment. The results are shown dramatically in Figure 1, with only CO2 having a negative relation to GDP, the other graphs, representing the other three groups in the Figure 7 have a positive relationship to economic growth three groups

Figure 10: Bivariate analysis of the four groups of indicators as per Figure 7, 1996-2012

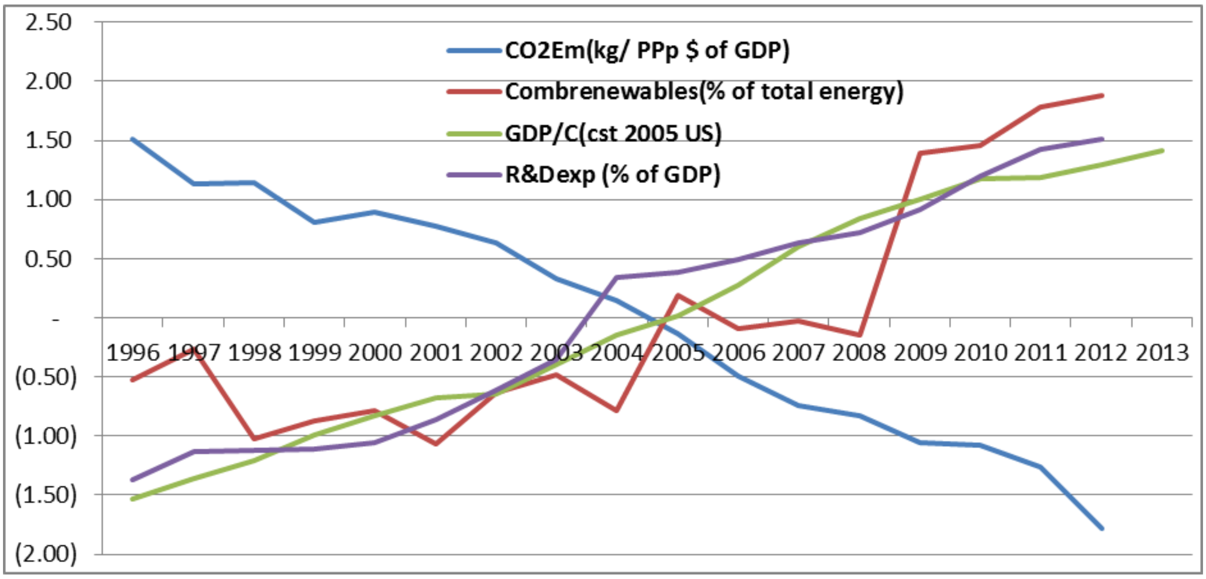


Table 2 of the correlations confirms this tendency as set out in Figure 10.

Table 2: Correlation Matrix[a]

Correlation Matrix[a]

		CO2Em (kg/ PPp $ of GDP)	Combrenewables (% of total energy)	GDP/C (cst 2005 US)	R&Dexp (% of GDP)
Correlation	CO2Em(kg/ PPp $ of GDP)		-,845	-,990	-,981
	Combrenewables(% of total energy)	-,845		,832	,842
	GDP/C(cst 2005 US)	-,990	,832		,980
	R&Dexp (% of GDP)	-,981	,842	,980	
Sig. (1-tailed)	CO2Em(kg/ PPp $ of GDP)		,000	,000	,000
	Combrenewables(% of total energy)	,000		,000	,000
	GDP/C(cst 2005 US)	,000	,000		,000
	R&Dexp (% of GDP)	,000	,000	,000	

a. Determinant = ,000 sig

The multivariate analysis using Principal Component Analysis (PCA) shows that the first axis (1) explains more than 90% of the inertia as shown in the table of variance, Table 3:

Table 3: Total Variance Explained

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3,740	93,490	**93,490**	3,740	93,490	93,490	2,509	62,730	62,730
2	,228	5,709	99,199	,228	5,709	99,199	1,459	36,469	99,199
3	,022	,562	99,762						
4	,010	,238	100,000						

Extraction Method: Principal Component Analysis.

The first axis opposes the variable CO2 particle emission to the variables, R&D expenditure and GDP growth. This means that the more increase of R&D expenditure and growth improvement, the less the environment is damaged by the CO2 particle emission. The second axis shows the importance the use of renewable energy in the economy. As seen in Table 4.

Table 4: Rotated Component Matrix

Rotated Component Matrix[a]

	Component	
	1	2
GDP/C(cst 2005 US)	,880	,465
CO2Em(kg/ PPp $ of GDP)	-,868	-,488
R&Dexp (% of GDP)	,865	,486
Combrenewables(% of total energy)	,481	,877

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

8. Discussion and Conclusion

The results show the positive relationship between the national efforts to integrate the SD issue in with economic growth. However, the results should be improved in the long run, and the evaluation suggests the use more specific indicators as conducted in this paper. At the same time, the results show the negative relationship between the sustainable efforts and the reduction of CO2 damage on environment. Also, this analysis shows that energy has begun to play a key role in Tunisia's economic and environmental development, but more efficiency of the energy policy is recommended and needs to be applied to the economic sectors.

Significantly, the national strategy already in operation should sustain the development of new ecological sectors that need investment and knowledge, and which could also reduce the level of unemployment. However, the analysis also shows that criteria for distributing R&D spending should be focused on strategic sectoral strategies in the area of water, energy, health, the environment. The creation of a public funds open to private sector participation could be envisaged for activities considered high risk to stimulate the development of new business with high value added in the issue of SD.

The contribution of this paper is to identify the conditions that are necessary for a paradigm shift in economic and ecological development in both public and private efforts to support and enhance the development of new potential niche of sustainable and innovative sectors. Thus, by exploring the new modes of coordination and cooperation between the actors, the ultimate aim is to build an ecological sustainability model of innovation that would emerge from which political economy policies can be combined with niche investments that are developing in new sectors related to sustainability, which can be applied to the Tunisian case in the transition from autocratic to democratic power.

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