Graz Economics Papers – GEP

GEP 2017–05

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October 2017

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October 4, 2017

Abstract

Clean Development Mechanism (CDM) investments have the two-fold objective of mitigating greenhouse gas emissions and contributing to sustainable development. But while the contribution to mitigation has been analysed extensively in the literature, the impact on development has barely been quantified empirically. This paper intends to address this latter gap by investigating the impact of different types of CDM investments on local employment generation. A dynamic panel regression model for the period 2004-2014 across Brazilian municipalities supports that some CDM projects have not only stimulated job creation beyond the renewable energy sector, but also had a contractive effect in some economic sectors. We find moreover a clear difference by project type: For waste handling and methane avoidance projects, overall employment increases while no such effect emerges for hydro projects. However, these job effects are mainly transitory, i.e. in the first or second year after the project's registration; the expansion effect can be explained as a result of local employment demands generated during the project's construction and operation phases. The lack of durability or the temporary effects in employment of these projects might question the contribution of their benefits to local sustainable development.

Keywords: Employment generation; clean development mechanism; industry; regional development; municipality level; Brazil; dynamic panel model.

1. Introduction

In order to achieve the 2°C target, mitigation measures have to be taken to cope with climate change by both industrialized and developing countries. With the Paris Agreement, mitigation efforts are required from both industrialized and developing countries, and industrialized countries are to assist developing countries in their efforts via international climate finance. To understand the effects of such climate finance for developing countries, this paper draws on experience from the Clean Development Mechanism (CDM) which was the primary instrument to support mitigation efforts in developing countries within the Kyoto Protocol.

This instrument had the dual objective of helping developed countries fulfil their commitments to reduce greenhouse gas emissions as well as to aid developing countries in achieving sustainable development (CDM-Article 12). Regarding this second goal, one of the most prominent benefits of CDM projects is their direct impacts on employment (Olhoff et al. 2004). It is expected that CDM investments bring a significant stimulus to the local economy of a project site, which may be reflected in increasing income opportunities and employment generation. However, while CO_2 reductions generate revenues to project developers in the form of Certified Emission Reductions[1] (CERs), and are moreover monitored by the UNFCCC, contributions to local sustainable development lacked of any similar reward as well as of any monitoring to verify its accomplishment.

The typical CDM projects in developing countries like Brazil are renewable energy projects (hydro, wind, biomass energy) and waste handling disposal projects (methane avoidance, landfill gas). While all these project types are capable of reducing greenhouse gas emissions and thereby generating CERs, the potential effects for employment generation differ considerably.

Renewable energy projects tend to be more labour intensive than conventional energy sources (Altener 2003; Ecotec 20002) and they have the potential to stimulate local employment through project's construction and operation and maintenance activities. Moreover, these projects could also induce employment benefits in other sectors such as agricultural and/or industrial through indirect demand of goods and services (del Rio and Burguillo 2008; Brown et al. 2012). But in addition to these positive effects on employment, also other effects may be triggered by renewable energy

[1] A CER is equal to 1 tonne of CO_2 equivalent (1 tCO_2 e).

projects. These projects might have the potential not only to induce expansive but also to induce contractive effects on employment, affecting electricity-intensive sectors such as manufacturing (Hillebrand et al. 2006; Aldy et al. 2011). The net result on local employment will depend on how much this last effect offsets the positive impact at the local level. Also waste handling and management are labour intensive sectors, but previous studies have found a comparatively smaller potential for employment generation (Subbarao and Lloyd 2011). The main difference to renewable energy projects is however that the required skill level e.g. in waste sorting is lower and that therefore low-skilled workers, who previously worked in other sectors like agriculture, can be employed and trained on the job.

Several papers have tried to investigate the achievements of CDM projects on employment generation inside and outside the renewable energy sector. However, most of these studies are ex-ante analyses based on information provided by the Project Design Document[2] (PDD) of the CDM project[3] (Lema and Lema 2013; He et al. 2014)[4], which is basically data on project's expected/ potential impacts at the local level, and thus it does not reflect what effectively occurred after project's implementation. The goal of this paper is therefore to contribute to the understanding of impacts of CDM investments on sectoral employment by using empirical data.

We draw on the experience of Brazil, which is the third largest country worldwide regarding registered CDM projects and hosted the first project worldwide in 2004[5]. More than 300 projects have been registered during period 2004-2014, and more than 50% of them have targeted the energy sector. One decade of hosting CDM projects makes Brazil an interesting case study to evaluate impacts over time. In this study, impacts across Brazilian municipalities will be explored.

This paper is structured as follows: section 2 presents the literature review on impacts of CDM on employment generation in the manufacturing sector, while section 3 characterizes the CDM project

[2] This document is central for the validation and registration of a CDM a project. It describes the project activities, duration and crediting period, baseline methodology, how the project is additional, the monitoring plan and stakeholder comments.

[3] Nussbaumer (2009) argues that the information provided by the PDDs are accurate and relative reliable since they represent official documents that are evaluated by the DNAs before approval and registration of any CDM project in host countries. However, CDM project developers might have incentives to overstate potential achievements in local sustainable development in order to obtain validation and registration from the corresponding DNA.

[4] One important drawback of using data from the PDD is that it only reflects potential or expected results and thus it does not represent effective or real impacts as a result of the implementation of the CDM project.

[5] The first CDM project registered in the pipeline was a landfill project in the municipality of Nova Iguacu, in the federate state of Rio de Janeiro.

portfolio in Brazil. Section 4 displays the methodological approach and data, while results from the regression analysis are shown in section 5. Finally, discussion and some conclusions are drawn in section 6.

2. Literature review

Diverse potential effects of implementing renewable energy projects in the economy have been analyzed and discussed in the literature. However, one of the most prominent and probably best promoted effects is the positive impact on local employment due to their labour intensive features of renewable energy technologies that notably contrast with conventional energy sources (Ecotec 2002). The most visible and direct effect on employment is that generated during project's construction (Altener 2003; May and Nilsen 2015) as well as during operation and maintenance activities, which might require low and high skilled workers (Ecotec 2002; del Rio and Burguillo 2008; Brown et al. 2012). Moreover, these projects may also induce cross-sectoral employment benefits in sectors such as agriculture, industry, services or construction through the creation of indirect demand of goods and services (Hillebrand et al. 2006; del Rio and Burguillo 2008; Brown et al. 2012). For instance, in the case of biomass technology, the agricultural sector can gain from the biomass production through planting and harvesting as well as from the switch from traditional and less profitable crops to biomass production (Altener 2003; El Bassam and Maegaard 2004). For wind technology, manufacturing can benefit from fabrication and/or assembly of components, while the construction sector could profit from the construction and installation of project's plant (Ecotec 2002; Komor and Bazilian 2005).

But in addition to these positive effects, also other employment effects may be triggered by renewable energy projects. These projects might have the potential not only to induce expansive but also contractive effects that could affect energy-intensive sectors such as manufacturing (Hillebrand et al. 2006). This contractive effect describes how the expansion of renewable energy could increase electricity prices and might affect manufacturing production costs, leading to a fall in production as well as a decrease in sectoral employment. If electricity cost is too high, even an increase in net imports could be experienced regionally (Aldy et al. 2011). The net result on local employment will depend on how much this last effect offsets the positive impact at the local level.

A second issue is that although the renewable energy project generates demand for manufacturing goods and services, it is likely that these goods have to be imported from other regions because specific manufacturing components are not produced everywhere; so this might benefit other localities outside the project's site (Adas 2003; del Rio and Burguillo 2008; Brown et al. 2012). Therefore, the cross-sectoral employment generation may not necessarily stimulate and promote local industry. Finally, a third issue is related to the durability or temporariness of the employment generated during project's life (Brown et al. 2012). Although these projects may contribute to job creation, not all renewable energy technologies might be able to generate sustained employment effects at the local level (Komor and Bazilian 2005). That might be the case for wind projects, which may greatly stimulate job creation mainly during construction phase, but not significantly during operation and maintenance stage (Simas and Pacca 2014); in contrast, biomass projects might tend to generate more stable job positions because of the extent of its production chain (del Rio and Burguillo 2008).

Regarding the economic impacts of CDM projects, the empirical literature has tried to assess local effects in households' income (Subbarao and Lloyd 2011; Bayer et al. 2013), employment generation (Sutter and Parreño 2007; Olsen and Fenhann 2008; Alexeew et al. 2010; Subbarao and Lloyd 2011; Wang et al. 2013) and technology transfer (Schneider et al. 2008; Dechezlepretre et al. 2009; Seres et al. 2009, 2010; Alexeew et al. 2010; Costa-Junior et al. 2013; Lema and Lema 2013). In the particular case of employment generation, findings are not conclusive (Wang et al. 2013). Some studies have reported positive contributions at the local level (Olsen and Fenhann 2008; UNFCCC 2011; Wang et al. 2013), while some have found no effects associated with the implementation of CDM projects (Sutter and Parreño 2007; Alexeew et al. 2010; Subbarao and Lloyd 2011). It is important to highlight that most studies have adopted qualitative rather than quantitative approaches[6] (Wang et al. 2013) and have relied on the information provided by the PDD of each CDM project (Lema and Lema 2013; He

[6] Some examples of qualitative approaches are checklists (Olsen and Fenhann 2008), scoring pattern methods (Subbarao and Lloyd 2011) or the Multi Criteria Assessment (MCA) method and its further adaptations (Sutter 2003).

et al. 2014). An important drawback of these data is that it only reflects expected impacts and thus it does not capture real impacts after implementing the CDM project (Nussbaumer 2009).

Very few studies have attempted to quantify impacts of CDM projects on employment using empirical data (Mattoo et al. 2009; Wang et al. 2013). Mattoo et al. (2009) implemented a multi-country and multi-sector CGE model to assess impacts of climate change financing on the industry sector in developing countries. Main findings indicate that these economies experience reductions in the manufacturing output and exports due to Dutch disease-type effects, but the intensity of these impacts will mainly depend on how carbon intensive the domestic industry is; so high carbon countries tend to be more affected than lower carbon ones. In addition, Input-Output models have also been used to explore cross-sectoral effects of CDM investments on employment; Wang et al. (2013) found that CDM projects in the Chinese power sector have caused direct job losses in this sector, but created indirect jobs in other sectors such as the manufacturing.

In the case of Brazil, no quantitative assessment has been conducted yet in the context of CDM, but qualitative techniques have been applied using data from the PDD as well as stakeholders' interviews. According to Fernandez et al. (2014), CDM projects have succeed in delivering positive employment effects in the short-term, during construction and operation phase, but failed to promote long-term benefits in some Brazilian states.

3. Registered CDM projects in Brazil

Brazil is a pioneering country in hosting CDM projects worldwide. The first CDM project was registered in Rio de Janeiro in November 2004, a landfill gas project located in the municipality of Nova Iguacú. As of 2015, there are totally 338 CDM projects registered in the Execute Board (UNEP, 2015). They can be divided according to their sectoral scope into two main categories: renewable energy or power projects (60%) and waste handling and disposal projects (35%). The rest of CDM investments (5%) are projects in the chemical and manufacturing industries.

Main project types in the renewable energy or power sector are hydro (45%), wind (27%) and biomass energy (22%); most predominant project's subtypes in this sector are: run-of-river hydroelectric power (hydro projects), wind (wind projects) and bagasse power (biomass energy projects). Regarding waste handling and disposal sector, methane avoidance (56%) and landfill gas (44%) projects are the most representative types; while main project's subtypes in this sector are landfill flaring, landfill power (landfill gas projects), and manure (methane avoidance).

With respect to project's scale, almost 70% of total are large, while the remaining 30% are small scale projects[7]. In the renewable energy sector, in a similar way, 70 % are large; in particular, almost 100% of the wind type projects are of this scale. In the waste handling and disposal sector, 61% are large projects; where the landfill gas type projects are large at almost 100%, while the methane avoidance at almost 80%. In terms of geographic distribution of projects along the Brazilian territory, this is very uneven. Macro regions where CDM projects were implemented are the South-east with 39.3% of the total; the North-east with 21.6%, the South with 19.2% and the Central-west with 14.5%. Few projects (5.6%) were implemented in the North (Amazonian), region characterized by its very high forest density.

More than 50% of renewable energy projects are located in the South-east and South region (30.4% and 22%, respectively), while 28% in the North-east. In the case of waste management and disposal projects, 51% of total are located in the South-east, 18% in Central-west and 17% in the South. One interesting fact is that almost 80% of the CDM projects in the North-east are investments in the renewable energy sector; this reflects the high potential of this region to host energy projects such as hydro and wind. Moreover, the distribution of CDM projects reflects a general division of the country, where the south and southeast are much more developed and industrialized than the north (Fernandez et al. 2012).

At the municipal level, the distribution of CDM projects by macro region is displayed in table 1. At the national level, 7.6% (or 425 municipalities) has at least one CDM project that was implemented during period 2004-2014. This number exceeds the total number of registered CDM projects (338) because, in some cases, some project's activities could have included more than one municipality. The macro region with the lowest percentage of municipalities with CDM projects

[7] There are several criteria applied to classified CDM projects into large or small categories, but basically main difference is their capacity to reduce CO_2 annually (up to 60 000 tons in the case of small scale projects) and thus their capacity to generate CER credits (Carbon Market Watch 2007).

respect to its total is the North-east (2.8% or 51 municipalities), while the region with the highest percentage is the Central-west (15% or 72 municipalities), followed by the South-east (10.1% or 168 municipalities).

Table 1
CDM in Brazilian macro regions: number of project by type and distribution across municipalities (Period: 2004-2014)

Region	Number of CDM Projects	%	CDM project type					Total munici-palities	Munici-palities with CDM	%
			Hydro	Wind	Biomass	Landfill	Methane			
North	18	5.3	9	0	2	3	1	449	25	**5.6**
North east	73	21.6	5	47	6	8	4	1793	51	**2.8**
Central-west	49	14.5	26	0	2	0	20	466	70	**15**
South-east	133	39.3	26	0	29	33	27	1668	168	**10.1**
South	65	19.2	28	0	7	7	12	1188	110	**9.3**
Total	**338**	**100**	**94**	**56**	**46**	**51**	**64**	**5564**	**425**	**7.6**

Source: UNEP, IBGE.

4. Methodological approach

4.1. Data

In order to assess the impacts of CDM projects on employment, we investigate effects on total and sectoral employment at the municipality level using a dynamic panel model for period 2004-2014. A detailed description of all variables is displayed in table 2. Regarding employment variables, we use the total employment growth rate, which is the annual growth rate of total employment[8] at the municipality level. To explore cross-sectoral effects, we evaluate impacts on sectoral employment growth rates for the following sectors: industry, agriculture, services and construction. The selection of these sectors is based on the empirical literature on renewable energy projects and its potential effects on sectoral employment. Main source of employment data is the Brazilian Ministry of Labor and Employment (MTE), from the Annual Report on Social Information (RAIS).

[8] Total employment encompasses data on 8 sectors: mining, manufacturing, services in the industry, construction, commerce, services, agriculture and public administration.

Table 2
Variables description

Variable	Description	Type	Source
Total employment growth rate	Annual growth rate of total employment at the municipality level	Dependent	MTE
Employment growth rate in the industry sector	Annual employment growth rate in the industry sector	Dependent	MTE
Employment growth rate in the agricultural sector	Annual employment growth rate in the agricultural sector	Dependent	MTE
Employment growth rate in the services sector	Annual employment growth rate in the services sector	Dependent	MTE
Employment growth rate in the construction sector	Annual employment growth rate in the construction sector	Dependent	MTE
CDM	Dichotomous variable: municipality with a CDM project at time *t*	Explanatory	UNEP
CER credits	Dichotomous variable: municipality with a CDM project that generated CER credits at time *t*	Explanatory	UNEP
GDP growth rate	Annual GDP growth rate	Explanatory	IBGE
Industry GDP growth rate	Annual GDP growth rate in the industry sector	Explanatory	IBGE
Agriculture GDP growth rate	Annual GDP growth in the agricultural sector	Explanatory	IBGE
Service GDP growth rate	Annual GDP growth in the service sector	Explanatory	IBGE
Population growth rate	Annual population growth	Explanatory	IBGE
Rural population	Percentage of rural population	Explanatory	IBGE

Regarding data on CDM, our CDM proxy[9] is a dichotomous variable that assigns "1" to those municipalities with a CDM project at time *t*; this starts from project's registration year onwards. In our analysis, only municipalities with one CDM project have been included in order to avoid cross-

[9] CDM project investment values were also considered to be used as a proxy variable in our analysis. However, since most values were based on calculations and not in the original investment value in the project, we adopted a dummy variable that identifies municipalities with and without CDM projects over time to have more reliable estimations.

effects among other projects[10]. Two project's categories has been analyzed: a) hydro projects (renewable energy sector), and b) methane avoidance (waste management and disposal handling sector). Other project's types such as wind, biomass and landfill gas were not included in the analysis due to sample size. Data on CDM comes from the CDM Pipeline Analysis and Database of the United Nations Environment Programme (UNEP).

We have also included a proxy for CER credits to evaluate its effect on the local economy. The proxy for CER is dichotomous variable where "1" indicates that a municipality has a CDM project that generated CER credits at time t or during its corresponding crediting period. This data is also available from the CDM Pipeline of UNEP. In addition, we have incorporated in the analysis other explanatory variables such as the real GDP growth rate as well as sectoral real GDP growth rates for the industry, agricultural and services sectors; population growth and percentage of rural population. These data come from the Brazilian Institute of Geography and Statistics (IBGE).

4.2. Methodology

The potential effects of CDM projects on employment may take some time to take place, the impact of lagged CDM variables have been analyzed through a dynamic panel model for period 2004-2014 across Brazilian municipalities where CDM projects were implemented. The dynamic panel model is estimated using instrumental variable technique, so a GMM approach will be applied (Arellano and Bond 1991). Equation (1) describes this model (Bond 2002), where $y_{i\,t-1}$ is the autoregressive term, x_{it} is a set of explanatory variables which could also include a lagged structure of them; ρ_i represents unobserved individual-specific effects, while ε_{it} is an error term.

$$y_{it} = \alpha y_{i\,t-1} + \beta x_{it} + \rho_i + \varepsilon_{it} \qquad (1)$$

The unobserved individual-specific effects are correlated with the autoregressive term by construction; thus, the Arellano-Bond estimator is constructed by first differencing to remove the panel-level effects and using instruments to form moment conditions. Lagged values of the dependent

[10] From the 425 municipalities with CDM investments, 349 municipalities had only one project.

variable are used to form the GMM-type instruments. One important model assumptions are no serial autocorrelation in the first differenced error term.

Although the coefficients of the autoregressive component (or the lagged dependent variable) are not directly interpreted, its incorporation allows for dynamics that might be relevant for recovering consistent estimates of other parameters in the model (Bond 2002). Some advantages of using GMM are that it can correct for unobserved heterogeneity, omitted variables bias as well as with potential endogeneity problems (Bond et al. 2001).

This technique can also be extended beyond of strictly exogenous variables and applied with predetermined and endogenous explanatory variables (Bond 2002). The regression analysis is run using Stata software version 14 and command "*xtabond2*". Results are displayed and discussed in the next sections. Details on the instrumental variables are displayed in the appendix

5. Results

As discussed in the previous section, the incorporation of an autoregressive component (or the lagged dependent variable) as explanatory variable in the model allows for dynamics that might be relevant for recovering consistent estimates of other parameters in the model (Bond 2002). Results using this approach or dynamic regression models have been run for two subsamples: hydro projects (table 3) and methane avoidance projects (table 4). In both cases, we have estimated impacts on total and sectoral employment (i.e.: industry, agriculture, services and construction sectors) at the municipality level. The selection of economic sectors is based on the empirical literature on renewable energy projects that explains how project's activities could involve and stimulate other economic sectors at the local level.

Results for the hydro project subsample (table 3) show that although we could not identify any significant impact of CDM on total employment, it is possible to observe effects in sectoral employment at the municipality level. The CDM variable in the industry employment model depicts small and significant effects in its 2-year and 3-year lags. This means that CDM projects had a delayed positive impact on manufacturing employment during the 2^{nd} year after project's registration, but then this effect turned negative during the 3^{rd} year.

Table 3
Regression models: Renewable energy
Hydro projects

Explanatory Variable	(1) Total employment	(2) Industry	(3) Agriculture	(4) Service	(5) Construction	(6) Commerce
AR(1)	0.16*** (0.06)	0.54*** (0.06)		0.56*** (0.06)	0.10 (0.09)	0.28** (0.12)
AR(2)		0.54*** (0.06)	0.178** (0.09)			0.15** (0.06)
CDM	-0.035 (0.045)	0.004 (0.005)	0.001 (0.003)	-0.005 (0.007)	-0.008 (0.005)	0.0009 (0.002)
CDM Lag 1	0.005 (0.042)	-0.003 (0.004)	0.003 (0.004)	-0.009 (0.006)	0.004 (0.008)	0.001 (0.003)
CDM Lag 2	0.014 (0.042)	0.008* (0.004)	0.005 (0.006)	0.005 (0.004)	0.0004 (0.006)	-0.001 (0.003)
CDM Lag 3	-0.033 (0.057)	- 0.008** (0.003)	0.003 (0.004)	0.009 (0.008)	-0.013 (0.006)	-0.001 (0.003)
CER	-0.012 (0.051)	0.004 (0.003)	-0.004 (0.005)	0.008 (0.005)	0.005 (0.005)	0.001 (0.002)
GDP growth	0.095 ** (0.056)					
GDP industry		0.003 ** (0.002)	-0.004 ** (0.002)		0.013*** (0.004)	0.002** (0.001)
GDP agriculture			0.002 ** (0.002)			
GDP services				0.016 ** (0.009)		
Population growth	0.017 ** (0.028)	0.016 ** (0.027)	0.016 ** (0.027)	0.015 ** (0.025)	0.040 (0.05)	0.01 (0.02)
Obs	**791**	**791**	**791**	**791**	**791**	**791**

Significance level: *** at 1%, ** at 5%, * at 10%
m1, m2: tests for first and second-order serial correlation respectively.

After project's registration, a CDM project could potentially contribute to generate employment at the local level through direct and/or indirect job creation during construction and operation/maintenance phase (UNFCCC 2012). Employment in the manufacturing may be induced by the project during the construction phase through e.g. demand of intermediate goods and services (Hillebrand et al. 2006; Brown et al. 2012). This is in line with findings from empirical research in the impacts of renewable energy projects (other than the CDM framework), where most significant and positive benefits of hydro projects on local employment took place during construction (short-term benefits); while very few employment opportunities were generated during operation and maintenance phase (Reddy et al. 2006; Koschel 2013; Chandy et al. 2013).

On the other hand, the demand for manufacturing goods might not necessarily take place inside a project's area (del Rio and Burguillo 2006; Brown et al. 2012); consequently, some level of manufacturing imports might be experienced (Adas 2003; Aldy 2011) with potential negative effects in local industry. Other significant explanatory variables in the industry employment model are the autoregressive term and the industry GDP growth, whose effects are positive as expected according to theory. In addition, no impacts have been reported for the CER proxy[11] on total and sectoral employment. No impacts of CDM have been identified in other sectoral employment models (i.e.: agriculture, services, construction and commerce) in municipalities with investments in hydro projects.

With respect to waste handling and disposal projects, results for the methane avoidance subsample (table 4) show significant effects of CDM in total and sectoral employment at the municipality level. In the case of total employment, the coefficient of the CDM variable depicted a small, but significant impact in the 1-year lag; so municipalities with CDM projects exhibited positive and transitory effects during its first year after project's registration. Moreover, transitory effects on employment have been found in the agriculture, services, construction and commerce employment models.

In the case of agricultural employment, the impact of CDM is significant and negative at registration's year; no significant effects have been reported for lagged CDM variables. Both the construction employment and the commerce employment model show a significant and positive impact of CDM also in the registration year and again no significant effects have been reported for lagged CDM variables. In the case of the service employment model, the lag structure of CDM presents positive and significant effects up to the second lag; but no significant impacts have been reported after the third lag. This reflects employment demands generated during operation phase. Methane avoidance projects may involve more labour intensive and low-skilled activities provided by other sectors; consequently, the service sector can benefit from job creation through activities that do

[11] We also run regressions by project type using as CER proxy the annual volume of certificates generated at the municipal level; no significant impacts were identified.

not require high qualifications such as collection, separation, among others. But in contrast to hydro projects, the industry employment model shows no significant results for methane avoidance projects.

Table 4
Regression models: Waste handling and disposal
Methane avoidance projects

Explanatory variable	(1) Total employment	(2) Industry	(3) Agriculture	(4) Service	(5) Construction	(6) Commerce
AR(1)	0.16 *** (0.06)	0.22 * (0.134)	0.29 *** (0.095)	0.37*** (0.086)	0.28 *** (0.09)	0.33*** (0.09)
AR(2)			0.051 (0.049)			
CDM	-0.020 (0.042)	0.00 (0.005)	-0.013 * (0.007)	0.015 ** (0.007)	0.004* (0.003)	0.007*** (0.002)
CDM Lag 1	0.042 ** (0.019)	-0.000 (0.006)	0.003 (0.006)	0.010 * (0.006)	-0.002 (0.004)	-0.002 (0.002)
CDM Lag 2	-0.012 (0.012)	0.004 (0.005)	0.000 (0.005)	0.005 ** (0.003)	0.001 (0.002)	-0.002 (0.002)
CDM Lag 3	-0.008 (0.017)	-0.002 (0.003)	-0.004 (0.006)	0.004 (0.003)	-0.002 (0.002)	-0.001 (0.002)
CER	-0.015 (0.015)	0.004 (0.005)	-0.001 (0.005)	-0.006 (0.005)	0.000 (0.005)	-0.001 (0.002)
GDP growth	0.123 *** (0.041)					
GDP industry		0.003 (0.005)	-0.001 (0.005)		0.024* (0.013)	-0.005 (0.003)
GDP agriculture			0.008 (0.005)			
GDP services				0.007 (0.009)		
Population growth	0.017 ** (0.028)	0.040 (0.038)	-0.115 ** (0.059)	0.015 (0.030)	-0.006 (0.019)	0.005 (0.19)
Obs	**630**	**630**	**630**	**630**	**630**	**630**

Significance level: *** at 1%, ** at 5%, * at 10%
m1, m2: tests for first and second-order serial correlation respectively.

The proxy for CER credits does not show any significant impact in any model. Although some CDM projects promised to share carbon revenues from the generation of CER credits with the municipal government to further contribute to the local development, it seems that the transfer may have not taken place. A potential explanation of this insignificant effect is that this rent was probably captured by the private sector in several ways (Martinez and Bowen 2012).

6. Discussion and conclusions

The regression analysis showed that CDM projects had mixed and transitory effects in sectoral employment at the local level. In the context of this research, the ability of CDM investments to create labour opportunities depends on several variables such as technology type and project's stage. Based on the assessment of two CDM project's types, our analysis showed that CDM hydro projects had a small, but significant impact only on industry employment and this effect is transitory (2nd year and 3rd year). No CDM effects have been reported in other sectors analysed. Regarding CDM methane avoidance projects, although no effects have been reported in industry employment, significant and temporary impacts have been identified in the agriculture, construction, commerce and service employment and overall employment. For both project's types, effects are mainly temporary.

Effects of implementing renewable energy projects will depend on the interdependency that already exists among economic sectors at the local level (Hillebrand et al. 2006), type of renewable energy technology and project's stage (Komor and Bazilian 2005; Sutter and Parreño 2007; del Rio and Burguillo 2008; Subbarao and Lloyd 2011) as well as on local socio-economic conditions, resource endowments and cultural features (Reddy et al. 2006; Dhakal and Raut 2011). Before implementing any renewable energy or waste management project, the challenge is to identify local needs as well as local potential in resources, in order to choose a suitable technology that could contribute to enhance local economic performance (Martinez and Bowen 2012).

Technologies such as wind or hydro that are more capital intensive, in contrast to landfill gas or biomass energy that are more labour intensive, may lead to smaller effects in employment, so we cannot expect sustained and significant impacts along project's life in all cases (Sutter and Parreño 2007; Subbarao and Lloyd 2011). This is in line with some empirical analysis of the impacts of hydro projects on employment, whose effects are very modest and temporary (Reddy et al. 2006).

Regarding the impacts of CER credits on employment, no significant results have been identified. Although some CDM projects promised to share carbon revenues from the generation of CER credits with municipal governments to further contribute to the local development, it seems that transfers may have not taken place; probably these inflows were captured by the private sector in several ways (e.g.: used to pay part or the whole financial loan acquired to implement the CDM project).

Given the heterogeneous level of economic growth among developing countries, further research might attempt to investigate impacts not only in emerging economies like Brazil, but also in least developed countries to compare effects under different socio-economic conditions and resource endowments; in addition, research could explore the possibility of spill-over effects between neighbouring municipalities.

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