EXPLORING FIRM-LEVEL INNOVATION AND PRODUCTIVITY IN DEVELOPING COUNTRIES

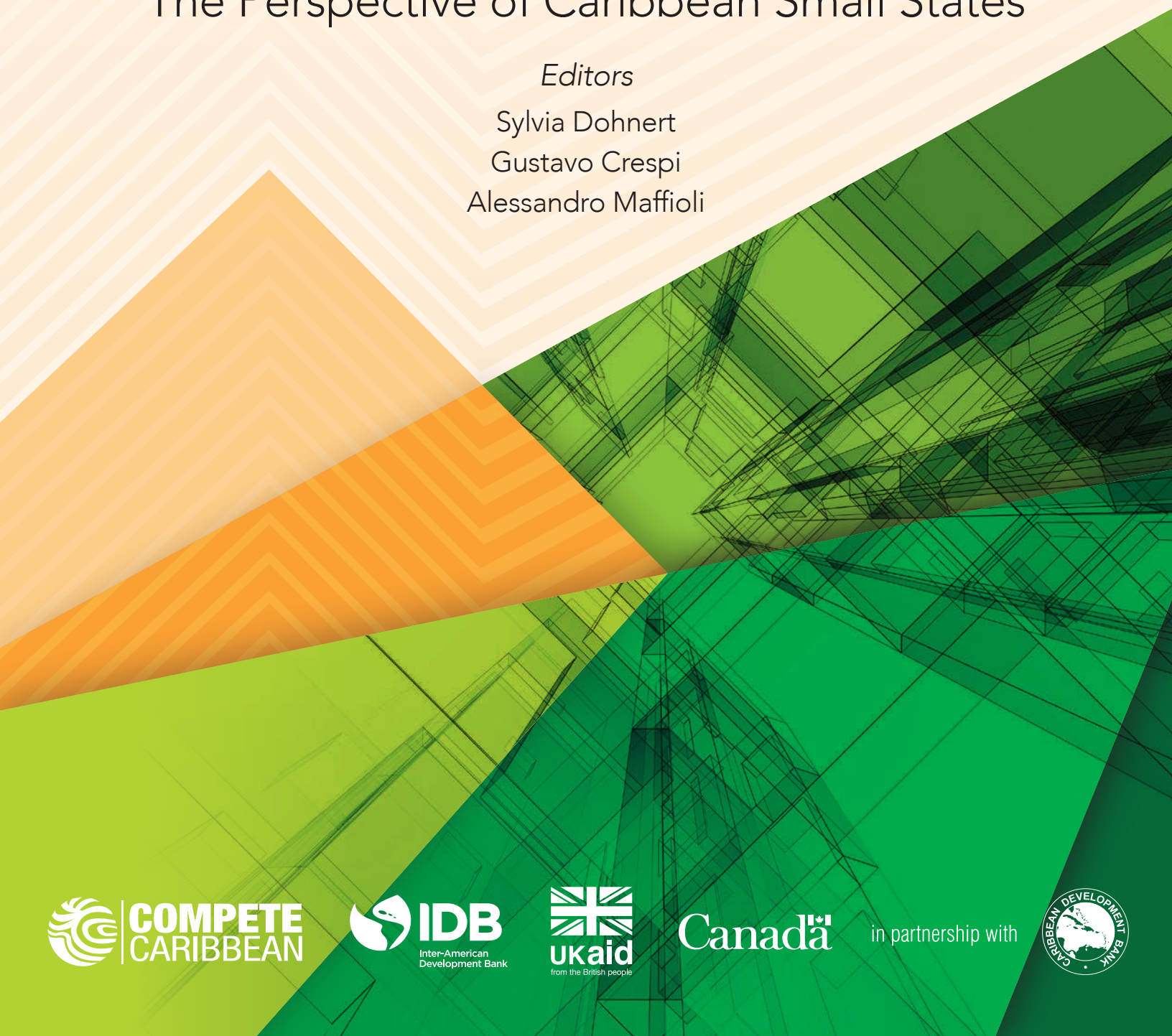
The Perspective of Caribbean Small States

Editors

Sylvia Dohnert

Gustavo Crespi

Alessandro Maffioli



COMPETE CARIBBEAN

IDB Inter-American Development Bank

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Compete Caribbean is a private sector development program that provides technical assistance grants and investment funding to support productive development policies, business climate reforms, clustering initiatives, and small and medium-size enterprise (SME) development activities in the Caribbean. The program, jointly funded by the IDB, Canada, and the United Kingdom Department for International Development, supports projects in 15 Caribbean countries. The program also partners with the Caribbean Development Bank to implement projects in the Organisation of Eastern Caribbean States. For more information, see www.CompeteCaribbean.org

Foreword

Recent theoretical and empirical literature suggests that, in the long run, growth in income per capita is the result of improvements in total factor productivity. To improve productivity, savings and investment are necessary; however, they are not sufficient on their own. Findings show the significance of innovation efforts in improving productivity. Policymakers and governments around the world have placed a great deal of attention on research and policy development and their investments have paid off in places like Korea, Singapore and the Netherlands, as well as closer to home in Chile and Mexico.

Unfortunately, the role of innovation and productivity in economic growth is poorly understood in the Caribbean, mainly due to a lack of data and communication about what we already know. The region is complex, made up of small, heterogeneous economies that differ in production structures, size, historical backdrops, and development trajectories from their Latin America counterparts and the advanced economies that have pioneered work in productivity improvement. Questions thus remain about how innovation and productivity affect the Caribbean and whether this issue needs to be a higher priority for policymakers.

This publication is intended to shed some light on innovation and productivity in the Caribbean. It begins this important discussion by providing a first ever, comprehensive evidence-based analysis of innovation and productivity at the firm level. The internationally comparable and statistically relevant data used herein come from two first-of-their-kind micro-level datasets funded by the Compete Caribbean Program: the Caribbean Enterprise Survey (CES) and the follow-up Productivity, Technology, and Innovation (PROTEqIN) survey. In a nutshell, the analytical findings confirm the relevance of innovation and productivity to the Caribbean region. Novel results expose how factors such as gender, finance, energy, competition, foreign direct investment, and, particularly, business development programs impact firm level innovation, productivity, and therefore economic growth.

I highly recommend this novel product to policymakers charged with the great task of implementing policies to help improve development conditions, academics conducting research in areas such as development economics and industrial economics, and citizens of the region who are confounded by the region's inability to improve its growth pattern and close the widening gap from more advanced economies. I am confident these findings will ignite new insights and motivate further research that can influence the design of current programs that support innovation activities and shed light on the relevance of these activities in enhancing economic development throughout the region.

In conjunction with the timely release of this knowledge product, we at the Competitiveness and Innovation Division of the Inter-American Development Bank (IDB) are delighted to usher in the second phase of the Compete Caribbean

Program (CCPII). The first phase positively affected the region by promoting private sector development that resulted in the program meeting or surpassing its set indicators and contributing to the development of innovative firms and policy support in competitiveness and innovation. The CCPII has been designed with a continued focus on promoting innovation and productivity that has been informed by the results of the program's final evaluation, lessons learned exercises, and by the findings summarized herein. The IDB, along with its partners at the UK's Department for International Development, Global Affairs Canada, and the Caribbean Development Bank are proud donors to the Compete Caribbean Program and remain committed to supporting economic development in the Caribbean.

José Miguel Benavente
Division Chief, Competitiveness and Innovation Division
Inter-American Development Bank

Acknowledgements

The Competitiveness and Innovation Division of the Inter-American Development Bank (IDB), in collaboration with Compete Caribbean, prepared this monograph. The editors, Sylvia Dohnert, Gustavo Crespi, and Alessandro Maffioli, have over 30 years of experience in developing the private sector in Latin America and the Caribbean.

This product benefited from the consistent support, valuable comments, and sage advice of many people at various stages. In particular, we acknowledge the guidance of Jose Miguel Benavente, Alejandro Carrion, Camilo Gomez, and Musheer Kamau, principally in selecting and helping to develop the papers that make up the various chapters. We are also grateful to the peer reviewers, Roberto Alvarez and Pierre Mohnen, for their strategic inputs. Wayne Elliott and Kayla Grant provided excellent coordination and research assistance, while Sarah Schineller oversaw the production process. The contents greatly benefited from the participation of the editors, authors, and other advisors at a Compete Caribbean workshop that took place in Bridgetown, Barbados in October 2015, where preliminary drafts and ideas were discussed.

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Executive Summary

Using micro-level data, this publication provides new and insightful findings on the determinants of firm innovation and productivity in a region with scarce empirical research: the Caribbean. Until very recently, the Caribbean did not have internationally comparable, statistically relevant data at the firm level to perform empirical analysis of what drives firm performance and innovation. The chapters that make up this publication use two datasets to examine the impact of different variables related to innovation and firm performance that are of interest to regional policymakers. The chapters are part of the "Cutting Edge Research on Productivity, Technology and Innovation" (RG-CC1066) research project, which was coordinated by the Competitiveness and Innovation Division of the Inter-American Development Bank (IDB).

As a collection, the chapters seek to unearth the relationship between different variables of interest and their impact on innovation, productivity, and/or performance at the firm level.[1] In turn, the variables of interest have been chosen to align with major areas of concern for policymakers in the Caribbean. The chapters provide answers to the following questions:

- Given that innovative firms in the Caribbean exhibit higher productivity (Mohan, Strobl, and Watson, 2016), what are the barriers to innovation that firms face in the region?
- In countries with very small markets, where scant economies of scale create difficult choices for regulatory agents, to what extent does competition (or the absence thereof) impact innovation?
- In a region where foreign direct investment inflows average 10 percent of annual gross domestic product, does foreign investment act as a knowledge transfer mechanism and increase innovation and productivity? If so, through what channels?
- In a region where firms seem to have disproportionate difficulties accessing finance compared to other economies, how do financing constraints affect innovation?
- In a region with female participation in ownership and management that is higher on average than in the rest of the world, how does the participation of women in Caribbean enterprises at an ownership or managerial level affect firm performance?
- In a region with very expensive and unreliable energy, how do firms respond to erratic energy supply? How does this impact their long-run strategy and economic performance?
- Finally, in a region with emerging programs to support innovation, what impact have these programs had on firm productivity?

[1] While these three concepts are not used interchangeably, other research has proven that innovation, productivity, and firm performance are positively correlated (Mohan, Strobl, and Watson, 2016; Crespi, Tacsir, and Vargas, 2014; among others).

References

Mohan, P., E. Strobl, and P. Watson. 2016. "Innovative Activity in the Caribbean: Drivers, Benefits and Obstacles." In M. Grazzi and C. Pietrobelli (eds.), *Firm Innovation and Productivity in Latin America and the Caribbean: The Engine of Economic Development*. Washington, DC: Palgrave Macmillan and Inter-American Development Bank.

Crespi, G., E. Tacsir, and F. Vargas. 2014. "Innovation Dynamics and Productivity: Evidence for Latin America." UNU-MERIT Working Paper Series No. 092. Maastricht, Netherlands: United Nations University – Maastricht Economic and Social Research Institute on Innovation and Technology.

1

What Micro-level Data Tell Us about Productivity, Innovation, and Growth in the Caribbean

Sylvia Dohnert, Gustavo Crespi, Alessandro Maffioli, and Kayla Grant

Over recent decades, the Caribbean region has been getting poorer as GDP growth rates have stagnated. The last rapid growth spurt—in the 1980s—was fueled mainly by the expansion of tourism, banana production, and public investments.[1] The literature links stagnation to very high debt levels,[2] the costs associated with frequent natural disasters (which in turn impact debt and growth), financial sector vulnerabilities, and weak overall competitiveness. There is also consensus that the economic growth challenges of the region are partly due to high labor, financing, and energy costs, but also to weak institutions and a complex business climate (IMF, 2013; CDB, 2013; Amo-Yartey and Turner-Jones, 2014; Ruprah, Melgarejo, and Sierra, 2014).

How much of the Caribbean's growth trajectory can be explained by country size? Historically, the discussion of growth in the Caribbean has been intertwined with the literature on small state exceptionalism. The literature indicates that small nations have more difficulties growing their economies because of scant economies of scale, weak diversification, vulnerability to trade shocks, location in regions of frequent natural disasters, limited pools of skills, and conflicting pressures on policymakers. More recent research dispels this current thinking, finding that size is not a binding constraint (Ruprah et al., 2014) and that, overall, small states do not have different per capita growth rates than other states (Easterly and Kraay, 2000).

Over the past few decades, the Caribbean's steady-state growth trajectory has been different—and slower—than a broader group of small nation states. Growth decomposition reveals that

[1] For the purpose of this document, the Caribbean region refers to the following 13 independent Caribbean Community (CARICOM) states: Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, Saint Lucia, St. Kitts and Nevis, St. Vincent and the Grenadines, Suriname, and Trinidad and Tobago.

[2] By 2015, 12 independent Caribbean countries had debt-to-GDP ratios above 60 percent. Estimates for the Caribbean indicate that when the debt-to-GDP ratio is above 56 percent, there is a negative marginal and average effect of debt on growth (Ruprah et al., 2014).

this growth gap is somewhat linked to lower levels of gross capital formation (especially private capital formation) in the Caribbean but, more importantly, to lower total factor productivity (TFP) growth over time (Ruprah et al., 2014). This finding aligns with research on the growth gap between Latin America and the United States over the past four decades, which identifies productivity gaps—not factor accumulation—as the main driver of the GDP per capita growth gap between those economies (Crespi et al., 2010).

Productivity starts at the firm level and is related to how efficiently firms convert inputs into outputs. Total Factor Productivity is an aggregate economic measure and is the proportion of national economic output that cannot be explained by changes in labor and capital inputs. Productivity is also a key economic measure of innovation (Jorgenson, 2011); however, not all firms are equally productive. Even in developed economies like the United States, there are large, ubiquitous, and persistent productivity differences among firms (Syverson, 2011). Reallocation of economic activity from lower toward higher productivity firms also largely explains aggregate economic growth (Foster, Haltiwanger, and Krizan, 2001).

The recognized importance of productivity for economic growth, coupled with the discovery of micro-level productivity differences among firms, has shaped several research agendas that seek to understand what influences varying productivity outcomes at the firm level. In the field of industrial organization, research has looked at the effect of competition, the amount of sunk costs, product market rivalry, technology spillovers, and organizational structures on productivity. The labor economics literature has explored the impact of human capital, incentive pay, managerial talent, managerial practices, organizational form, and social connections among coworkers. The trade literature has examined how productivity dispersion patterns affect trade (Syverson, 2011).

Clearly, an analysis of the determinants of the productivity of Caribbean firms would help inform policymakers about mechanisms to jump-start growth. However, until very recently, there was no data available to conduct such research, as statistical offices in the region did not conduct industrial census and/or business surveys. In 2010, the Compete Caribbean Program (a private sector development, technical assistance program funded by the Inter-American Development Bank [IDB], the Government of Canada, and the United Kingdom's Department for International Development and executed in partnership with the Caribbean Development Bank) sponsored the inclusion of 14 Caribbean countries in the World Bank's Latin American and Caribbean Enterprise Survey (LACES).[3] Four years later, Compete Caribbean funded a follow-up Productivity, Technology, and Innovation (PROTEqIN) survey of 13 of the previously surveyed countries.[4] These two datasets resulted in a panel dataset that could be used to conduct robust analyses over time.

LACES followed the World Bank Enterprise Survey (WBES) methodology.[5] Business owners and top managers of formal firms in the manufacturing and services sectors and with more than five employees were interviewed. Following the guidelines of the methodology, 360 firms were surveyed in each of the larger countries in the sample (The Dominican Republic, Jamaica, and Trinidad and Tobago), and 150 firm interviews were conducted in each of the other countries. The surveys used the stratified random sampling methodology. Homogeneous groups were created based on firm size[6] and business sector,[7] and simple random samples were selected within each group. The dataset included firm-level behavior such as sales, supplies,

[3] The 14 countries were Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, The Dominican Republic, Guyana, Grenada, Jamaica, Saint Lucia, St. Kitts and Nevis, St. Vincent and the Grenadines, Suriname, and Trinidad and Tobago.

[4] The Dominican Republic was not included in the PROTEqIN survey.

[5] The WBES methodology is available at https://www.enterprisesurveys.org/methodology.

[6] Size was defined as small (5–19 employees), medium (20–99 employees), or large (100+ employees).

[7] Business sector was defined as manufacturing, retail, or other services.

foreign trade, competition, innovation, conflict resolution, crime prevention, business environment, government relations, labor and skills, financing, and performance.

The PROTEqIN survey was designed as a panel survey of LACES, with new sections and variables. The survey targeted 1,680 respondents drawn from the 2010 LACES, aiming to update the data from firms that had participated in that survey and to capture additional information on firm performance, finance, gender of ownership and management, use of productive development programs, and issues related to management style, innovation, and crime, among others. The final survey included 1,966 respondents, 286 more than the targeted sample.[8] The questionnaire had 830 variables. Like LACES, the survey concentrated on non-agricultural, formal establishments with a minimum of five employees, and its sample was stratified by industry and size. The same private contractor conducted both surveys. Table 1.1 shows the sample sizes in each survey.

Although LACES and the PROTEqIN survey were a major step forward for a better understanding of the micro-level determinants of productivity and innovation in the Caribbean, findings need to be evaluated with care, taking into consideration the typical limitations of large-scale surveys. First, findings are only valid for firms larger than a given sampling threshold (in this case five employees), so results cannot be extrapolated to micro-enterprises, which are very common in the Caribbean. Also, and perhaps more importantly, the sampling framework comes from the population of formal firms, thus analytical work on the determinants of informality cannot be done based on LACES and PROTEqIN. Second, although the sectoral coverage of the sample considers manufacturing and important portions of the services sectors, it does not include agricultural and extractive industries that might be relevant for some Caribbean countries. Finally, when working with the panel data (data from both surveys), there is the problem of attrition (some firms did not survive from the period of LACES to that of the PROTEqIN survey), which might affect the representativeness of the results. Despite these limitations, LACES and PROTEqIN provide invaluable information that can be used to analyze productivity and innovation at the micro-enterprise level in the Caribbean.

TABLE 1.1. Number of Firms in Each Survey and Total Number of Observations

Country	LACES	PROTEqIN	Number of Observations
Antigua and Barbuda	151	131	282
Bahamas, The	150	127	277
Barbados	150	123	273
Belize	150	122	272
Dominica	150	126	276
Dominican Republic	360	—	360
Grenada	153	129	282
Guyana	165	70	235
Jamaica	376	242	618
Saint Lucia	150	128	278
St. Kitts and Nevis	150	125	275
St. Vincent and the Grenadines	154	133	287
Suriname	152	94	246
Trinidad and Tobago	370	340	710
Total	2,781	1,890	4,671

Sources: LACES and PROTEqIN.

These datasets provided researchers previously unavailable opportunities to explore the relationship between growth, productivity, and private sector activity in the Caribbean. For example, using the LACES dataset and comparing it to enterprise surveys in other small economies, Ruprah et al. (2014) found that Caribbean firms performed

[8] The sample incorporated new enterprises in Suriname and Guyana and extended the size of the survey in Trinidad and Tobago to 340 firms. The additional respondents were included using the stratified random sampling methodology used for LACES.

poorly between 2007 and 2010 in terms of sales growth, employment growth, and productivity, even adjusting for lower rates of growth in the Caribbean over that period. They also found significant differences between the profiles of Caribbean firms and those in other small economies. Caribbean businesses tended to be smaller (three quarters had less than 20 full-time employees), older (more than 20 years in operation), and less involved in foreign trade than their other small economy counterparts. Moreover, Caribbean firms were concentrated in the tourism and retail sectors in middle-sized jurisdictions, and ownership was predominantly local. In the economic development literature, these business characteristics are not typically associated with dynamism.

Mohan et al. (2016) used the LACES dataset to identify the relationship between productivity and innovative activity at the firm level in the Caribbean. They verified that innovative firms in the region exhibited higher labor productivity compared to non-innovative firms. Certainly, some differences in firm characteristics accounted for some of the observed differences in productivity, such as size, access to public support for innovation, ownership of patents, export behavior, foreign ownership, and cooperation with other institutions for innovation. However, even after adjusting for these differences, the productivity mean for innovative firms was higher and there was less dispersion in productivity than for non-innovative firms.

Cathles and Pangerl (2016) used both datasets to understand what variables affect labor productivity in the Caribbean as firms move between productivity quintiles. In line with results of similar research for Latin America (e.g., Arias et al., 2012), they found that size, whether the firm had a website, and the percentage of full-time employees with at least a bachelors' degree affected productivity. They also found that firms in higher productivity quintiles that reported access to finance as their biggest obstacle underperformed firms in the same quintile who did not report this barrier as their biggest obstacle. Cathles and Pangerl (2016) demonstrated how the business climate affected productivity. Indeed, recent research on productivity worldwide has shown that, while some factors that affect productivity are under the control of firm managers (e.g., managerial talent, input quality, research and development [R&D], innovation, and learning), other factors (e.g., rules, institutions, and other elements of the business climate) are outside a firm's control but still impact aggregate productivity by affecting the firm's ability to allocate resources to higher productivity uses (Syverson, 2011). This characteristic is referred to as the allocative miss-allocation of economic resources.

To stimulate further original analytical research on the micro-determinants of productivity in the Caribbean, Compete Caribbean launched a global competition for research papers using the two datasets. The call had two objectives. First, to motivate research that could help identify the possible effect and causal role of public policies and market failures on firm-level productivity and innovation in the Caribbean. This objective extended to evaluating whether market failures or public policies stunt firm growth and/or allow for relatively inefficient producers to operate profitably. Second, the call sought to stimulate research that would extend knowledge of drivers of innovation and productivity in the Caribbean and how they compare with other regions, specifically attempting to clarify the role played by micro-economic, structural, and political economy factors. Researchers were encouraged to paint a clear picture of the typology of Caribbean firms—illustrating their current strengths, weaknesses, opportunities, and threats in terms of productivity and innovation—and to provide, to the extent possible, policy recommendations stemming from rigorous analytical and evidence-based research. Particular subject matters of interest in relation to productivity were proposed, such as access to finance, labor markets, business climate, government support programs, use of technology, gender, and environment. This was not an exclusive list.

The chapters herein constitute the winning research projects, covering a variety of topics that are important to the region. The compilation touches on some of the topics examined in *Firm*

Innovation and Productivity in Latin America and the Caribbean: The Engine of Economic Development (Grazzi and Pietrobelli, 2016). As such, some of the themes included in that book resurface in the present publication, such as innovation and productivity, the impact of credit on performance, and the effects of foreign direct investment (FDI) on productivity, but with the analysis focused on the Caribbean and benefiting from PROTEqIN, an additional Caribbean-specific dataset. As a collection, the chapters answer the following questions:

- Given that innovative firms in the Caribbean exhibit higher productivity, what are the barriers to firms innovating?
- In a region where firms seem to have disproportionate difficulties in accessing financing compared to other economies, how does this constraint affect innovation?
- In countries with very small markets, where scant economies of scale pose difficult regulation choices, to what extent does competition (or the absence thereof) impact innovation?
- In a region where FDI inflows average 10 percent of annual GDP, does foreign investment act as a knowledge transfer mechanism and increase innovation and productivity? If so, through what channels?
- In a region with female participation in ownership and management that is higher on average than that of the rest of the world, how does this variable affect firm performance?
- In a region with very expensive and unreliable energy, how do firms respond to erratic energy supply? And, how does erratic energy supply impact their long-run strategy and economic performance?
- In a region with emerging programs to support innovation, have these had any impact on firm productivity?

In Chapter 2, Preeya Mohan, Eric Strobl, and Patrick Watson explore the impact of barriers to innovation in the Caribbean. Their research is novel in that it distinguishes between barriers that affect the behavior of innovative firms—revealed barriers—from those that inhibit potentially innovative firms—deterring barriers. Potential innovators are defined as firms that are not currently innovating but that are interested in innovating within the next three years. The global literature on innovation barriers tends to only focus on the revealed barriers of innovative firms. By including potentially innovative firms, the authors' analysis helps address the policy question of which innovation barriers are crucial in inhibiting innovation by non-innovative firms that are interested in innovating. This question is relevant for the Caribbean since, while the proportion of firms that are innovators is relatively small (26 percent of surveyed firms), there is a much larger proportion of potential innovators (59 percent of surveyed firms).

The barriers examined were financing and cost, knowledge, market, and policy and regulation. The authors used the Crépon, Duguet, and Mairesse (1998) model and an augmented Cobb-Douglas production function to model the firm's innovation decision and the size of the innovation effort, while taking into account innovation barriers. Similar to other literature, they found that the determinants that increased the likelihood of a firm deciding to engage in innovative activities were size, whether the firm exported, the presence of an R&D department, competition (formal and informal), and patent protection. In contrast to other literature, however, foreign ownership in the Caribbean did not increase a firm's decision to innovate.

With respect to the decision to innovate, they found that all four types of barriers made the decision to innovate difficult, but only cost (the level of available financial resources and direct public funding for innovation) and market (time to market) barriers were significant. Similar to other literature, they found the cost barrier to be the most important. Potentially innovative firms experienced relatively higher barriers than innovators regardless of the barrier considered. With respect to the amount of effort placed on innovation, they found that exporting, competition, and patent protection positively affected innovation expenditures, while foreign ownership, public financial assistance, and

cooperation did not seem to predict innovation expenditures. The four barriers previously described negatively affected innovation expenditures, with the cost barrier having the largest negative impact.

In Chapter 3, Diego Morris explores the impact of access to financing on innovation. Given that innovation is costly and risky, and that, as Mohan et al. document in chapter 2, cost barriers have the largest negative impact on innovation, how do restrictions on financing impact the innovation behaviors of firms?

Morris developed a baseline model with a six-tier index that increased in intensity the more categories under which a firm qualified as financially constrained. He found strong evidence of a negative relationship between innovation and access to financing, which is consistent with the global literature on this topic. However, constraints on access to financing seemed to negatively affect process innovation more than product innovation. Other interesting findings were that increasing the proportion of skilled workers increased the likelihood that a firm would innovate; managerial experience positively influenced the likelihood of process innovation, albeit marginally; and firms that considered government regulations burdensome were less likely to undertake product innovation, but there was no such evidence for process innovation.

In Chapter 4, Antonio Marcos Hoelz Pinto Ambrozio and Filipe Lage de Sousa explore the impact of competition on innovation behavior in the Caribbean. Most of the literature exploring the relationship between competition and innovation uses firm-level data from developed countries, so by using a dataset from a developing region to test for this relationship, the authors contribute to an expanded understanding of this topic. The chapter makes a further contribution to the literature by distinguishing between the effects of formal and informal competition on innovation.

In line with the global literature, Ambrozio and de Sousa found that firms tended to increase their expenditures on innovation when competition rose, but the power of competition to drive innovation decreased after a certain threshold, corroborating the existence of an inverted U-shape relationship. They also found that the current level of competition in the region was below the maximum threshold, which may indicate that there is still room to stimulate innovation expenditures by promoting more competition. Interestingly, they found that competition from the informal sector also stimulated innovation expenditures and exerted even more pressure than formal competition. These findings present interesting policy options and dilemmas, as well as further research questions.

The development literature posits that one of the potential benefits of FDI is knowledge transfer to local firms. In Chapter 5, Preeya Mohan, Eric Strobl, and Patrick Watson examine whether foreign firms in the Caribbean stimulate other firms to undertake innovative activity through (1) intra-firm spillover effects, (2) horizontal spillover effects (labor mobility or demonstration effects), and (3) the purchase of foreign goods and services.

Their research showed that, while foreign firms in the Caribbean tended to engage more in innovative activity (spent on innovation, had an R&D department, cooperated on innovation, used a licensed technology, had patents) and had more innovative outputs (product, process, market, and organizational innovation) compared to local firms, their innovative activity did not influence local firms to decide to innovate. There also did not seem to be a knowledge transfer effect from foreign firms to local firms through worker mobility in the same or related industries. On the other hand, the use of foreign material inputs by domestic firms increased the likelihood that the firm would undertake product or process innovation. The use of foreign inputs by domestic firms also positively affected labor productivity, while foreign ownership and the sector's share of foreign employment did not have a significant impact on labor productivity.

In Chapter 6, Winston Moore, Andrea F. Presbitero, and Roberta Rabellotti investigate whether the presence of a female owner or manager impacts firm productivity in the Caribbean. They found that the proportion of female-owned or managed firms in the Caribbean was higher than

expected compared to other countries where LACES data is also available. The authors compared women-owned or managed firms in the Caribbean to comparable firms across certain characteristics that are known to impact productivity and found no gender gap in the propensity to innovate, firm age, or the propensity to export. However, women-owned or managed firms tended to be significantly smaller, were less likely to demand bank credit, indicated access to financing as a severe obstacle to their business, and were less likely to take advantage of technical assistance than comparable firms. The analysis further explored whether there was a productivity gap associated with female participation in ownership or management, controlling for firm characteristics and country and sector fixed effects. The results suggest that women-managed firms were in fact less productive than comparable firms. This result was not valid for women-owned firms, which were as productive as comparable firms.

In Chapter 7, Manuel Barron assesses how firms in the Caribbean react to unreliable electricity supply by analyzing the relationship between outages and firm behavior. This is an important issue in the Caribbean, where, according to PROTEqIN and LACES, 42 percent of firms own generators and use them to generate from 10 to 16 percent of their electricity needs.

The analysis revealed that firms responded to the issue of erratic power supply by reducing capacity utilization and shedding jobs-mainly permanent positions. A one-standard deviation increase in outages was associated with a 3 percent reduction in employment. Women lost most of the jobs. The estimated annual reductions in wages in the median firm due to reduced jobs amounted to US$40,000. Outages also affected firms' investment in innovation. Firms with higher exposure to outages were less likely to introduce innovations in goods or services, suggesting that firms were allocating the resources that would have been used for innovation to self-generation. These findings suggest that unreliable power supply may have long-term consequences for firm performance and industry development.

In Chapter 8, Federico Bernini, Lucas Figal Garone, and Alessandro Maffioli explore how public support programs for innovation and business development have worked in the Caribbean. They examined the datasets to understand the determinants of program participation and found that larger, more productive, national firms were more likely to participate in support programs. Interestingly, firms that participated in publicly funded innovation programs experienced concrete impacts on sales and the ability to develop new goods and services or improve their production processes, and spent more on innovation as an intermediate outcome. Firm participation in training programs also generated a higher probability of a firm training its employees. Finally, they found that these two characteristics (investment in innovation and employee training), correlated with participation, had direct effects on firm productivity. Interestingly, those firms that admitted to having avoided taxes, as well as female-owned firms, participated less in support programs. The concluding chapter discusses what these findings mean for the region and suggests policy recommendations and future areas of research.

References

Amo-Yartey, C., and T. Turner-Jones. 2014. *Caribbean Renewal: Tackling Fiscal and Debt Challenges.* Washington, DC: International Monetary Fund.

Arias, E., G. Crespi, E. Tacsir, F. Vargas, and P. Zuñiga. 2012. "Innovation for Economic Performance: The Case of Latin American and Caribbean Firms." Competitiveness and Innovation Division, Institutions for Development Technical Note No. 494. Washington, DC: Inter-American Development Bank.

CDB. 2013. *Public Sector Debt in the Caribbean: An Agenda for Reduction and Sustainability.* St. Michael, Barbados: Caribbean Development Bank. Available at http://www.caribank.org/uploads/2012/05/Public-Debt-in-the-Caribbean-An-Agenda-for-Reduction-and-Sustainability.pdf.

Cathles, A., and S. Pangerl. 2016. "Different Obstacles for Different Productivity Levels? An Analysis of Caribbean Firms." In M. Grazzi and C. Pietrobelli (eds.), *Firm Innovation and Productivity in Latin America and the Caribbean: The Engine of Economic Development.* Washington, DC: Palgrave Macmillan and Inter-American Development Bank.

Crépon, B., E. Duguet, and J. Mairesse. 1998. "Research, Innovation and Productivity: An Econometric Analysis at the Firm Level." *Economics of Innovation and New Technology* 7(2):115–58.

Crespi, G., D. Giuliodori, R. Giuliodori, and A. Rodriguez. 2016. "The Effectiveness of Tax Incentives for R&D+I in Developing Countries: The Case of Argentina." *Research Policy* 45(10):2023–35. Available at http://www.sciencedirect.com/science/article/pii/S0048733316301135.

Easterly, W., and A. Kraay. 2000. "Small States, Small Problems? Income, Growth, and Volatility in Small States." *World Development* 28(11):2013–27. Available at https://williameasterly.files.wordpress.com/2010/08/25_easterly_kraay_smallstatessmallproblems_prp.pdf.

Foster, L., J. Haltiwanger, and C. J. Krizan. 2001. "Aggregate Productivity Growth: Lessons from Microeconomic Evidence." In C. R. Hulten, E. R. Dean, and M. J. Harper (eds), *New Developments in Productivity Analysis*, pp.303–63. Chicago and London: University of Chicago Press.

Grazzi, M., and C. Pietrobelli. 2016. *Firm Innovation and Productivity in Latin America and the Caribbean: The Engine of Economic Development.* Washington, DC: Palgrave Macmillan and Inter-American Development Bank.

IMF. 2013. "Caribbean Small States: Challenges of High Debt and Low Growth." Washington, DC: International Monetary Fund. Available at https://www.imf.org/external/np/pp/eng/2013/022013b.pdf.

Jorgenson, D. W. 2011. "Innovation and Productivity Growth." *American Journal of Agricultural Economics* 93(2):276–96.

Mohan, P., E. Strobl, and P. Watson. 2016. "Innovative Activity in the Caribbean: Drivers, Benefits and Obstacles." In M. Grazzi and C. Pietrobelli (eds.), *Firm Innovation and Productivity in Latin America and the Caribbean: The Engine of Economic Development.* Washington, DC: Palgrave Macmillan and Inter-American Development Bank.

Ruprah, I., K. A. Melgarejo, and R. Sierra. 2014. "Is there a Caribbean Sclerosis? Stagnating Economic Growth in the Caribbean." Washington, DC: Inter-American Development Bank.

Solow, R. M. 1957. "Technical Change and the Aggregate Production Function." *Review of Economics and Statistics* 39(3):312–20.

Syverson, C. 2011. "What Determines Productivity?" *Journal of Economic Literature* 49(2):326–65. Available at http://home.uchicago.edu/syverson/productivitysurvey.pdf.

2

Barriers to Innovation and Firm Productivity in the Caribbean

Preeya Mohan, Eric Strobl, and Patrick Watson

Innovation has long been associated with productivity growth since it is believed to result in the more effective use of a firm's resources and the adoption and development of new technology. Indeed, there is ample empirical evidence in the literature that firms that engage in innovation are more technologically advanced and have higher labor productivity, enabling them to better compete internationally (Schumpeter, 1939; Griliches, 1986; Freeman, 1994; Griffith et al., 2006; Mairesse and Mohnen, 2010). Furthermore, there is evidence that investment in innovation results in a country experiencing sustainable long run growth and development (Hall and Jones, 1999; OECD, 2009; Rouvinen, 2002). However, a large number of firms—both innovative and potentially innovative—are unable to innovate because they face numerous barriers. In this regard, D'Este et al. (2008) distinguish between revealed barriers, which impede an innovative firm's achievement of innovation and constrain innovative success, and deterring barriers, which prevent a potentially innovative firm from engaging in innovation activities. Also, these barriers can be classified as internal and external and are related to factors such as financing and cost, market, knowledge, and policy and regulation.

Examining the impediments to innovation success is relevant to policy development. More specifically, much government policy aims to tackle obstacles to innovation and alleviate barriers by designing and implementing appropriate policies and incentives for firms to engage in innovation activities and reduce failures. Therefore, it is important to know which barriers are particularly relevant and constraining for innovative and potentially innovative firms. Identifying and subsequently reducing these obstacles should help increase the number of innovative firms and the level of innovation, thus leading a country to increased productivity and growth and development. From the perspective of firms, it is important to identify innovation barriers since this may provide valuable information for entrepreneurs and managers when crafting innovation strategy, such as introducing new products and processes, and may increase the chances of success and economic pay-off from innovative activity.

Considering barriers to innovation within the Caribbean, there is a general paucity of studies on firm innovation and productivity in Caribbean Small Island Developing States (SIDS). Moreover, the few studies tend to group the Caribbean together with

large Latin American countries and focus mainly on manufacturing and agro-processing sectors (Lederman et al., 2014; Ortiz et al., 2012; Daude and Fernández-Arias, 2010; IDB, 2010; Crespi and Zuniga, 2012). However, in Caribbean SIDS, services play a much more important role than manufacturing. Mohan, Strobl, and Watson (2014) is one exception: these authors looked specifically at Caribbean SIDS and included the services sector. Nevertheless, these studies, including Mohan et al. (2014), investigated the determinants of innovation and the benefits from it only in terms of making firms more productive and not barriers to innovation. The findings suggest that innovation and productivity are quite low and, indeed, are acute constraints to growth and development in the region. Therefore, firms in the region potentially face high barriers to innovation. Indeed, in the study by Mohan et al. (2014), just 11 percent of the firms in the region that were surveyed engaged in any type of innovation activity.

This chapter presents innovation barriers related to financing and cost, market, knowledge, and policy and regulations facing firms in 13 Caribbean SIDS. Further, it studies the impact of these factors on innovation and productivity for innovative and potentially innovative firms using Compete Caribbean's Productivity, Technology, and Innovation Survey (PROTEqIN).

Literature Review

The literature on innovation barriers has mostly concentrated on differences in characteristics that affect the perception of barriers among innovative firms only (Galia and Legros, 2004; Mohnen and Rosa, 2001) and has treated non-innovative firms as an undifferentiated group (Baldwin and Lin, 2002; Hölzl and Friesenbichler, 2010; Iammarino, Sanna-Randaccio, and Savona, 2009). However, innovative firms experience barriers to increasing current innovation activities, while non-innovative firms that have an interest in innovation face barriers to starting innovation activities. D'Este et al. (2008) therefore distinguish between *revealed barriers*, which impede a firm's innovation success and affect innovative firms, and *deterring barriers*, which constrain a firm's innovation effort and affect innovative and non-innovative firms. Only a small number of studies have addressed non-innovative firms (D'Este et al., 2008, 2012; Savignac, 2008; Mohnen et al., 2008), and these studies found that non-innovative firms that do not wish to innovate rank barriers as low, while non-innovative firms with an interest in innovation rank barriers just as high as innovative firms.

Since the majority of studies have focused on barriers faced by innovative firms only, the literature fails to identify the different nature of the barriers in terms of their revealed versus deterring effects, and the context in which they might co-exist. Thus the study of barriers faced by innovative firms does not address the main policy question of which innovation barriers are crucial in inhibiting non-innovative firms with an interest in innovation in starting innovation activities. A study of non-innovative firms that distinguishes between those that are interested in innovation and those that are not could provide information on two neglected issues: whether differences among non-innovative firms exist in relation to their assessment of barriers, and what features distinguish non-innovative firms from each other and from innovative firms. Additionally, including firms not willing to innovate in the sample may create a positive spurious correlation between perception of barriers and firm innovativeness (Savignac, 2008; Mancusi and Vezzulli, 2010) and may overestimate the role of revealed barriers while underestimating or ignoring deterring barriers. Moreover, studies of non-innovative firms that are not willing to innovate has led to conclusions of a negative relationship between innovation intensity and innovation barriers (Mancusi and Vezzulli, 2010; Savignac, 2008).

Questions about barriers in innovation surveys cause firms to evaluate the problems they face and overcome in carrying out innovation activities: revealed barriers. However, the questions do not indicate whether these challenges represent an actual obstacle to pursuing innovation: deterring barriers. Thus, the literature is mainly focused on revealed barriers. However, carrying out innovation increases a firm's awareness of the difficulties that

are likely to be encountered, without necessarily preventing them from pursuing innovation activities (Baldwin and Lin, 2002; Galia and Legros, 2004). The majority of the empirical studies based on these innovation surveys investigated factors that affected perceptions of the importance of innovation barriers, since engagement in innovation activity increases the firm's awareness of these barriers but does not necessarily prevent them from being successful innovators. The findings show that the greater the firm's involvement in innovation, the greater the importance attached to these barriers. Thus innovative firms are more likely to have experienced barriers to innovation and are more likely to recognize them as significant challenges to innovation activities. The perception of revealed innovation barriers may slow but not prevent innovative firms from engaging in innovation activities (Galia and Legros, 2004). Additionally, these barriers may serve as an indicator of how successful the firm is at overcoming them (Baldwin and Lin, 2002; Tourigny and Le, 2004).

In a study of Canadian manufacturing firms, Baldwin and Lin (2002) concluded that a larger proportion of innovators reported that innovation barriers negatively affected innovation intensity compared to non-innovators. Similarly, in a study of Canadian service firms which were innovators, Mohnen and Rosa (2001) also found that the most innovation intensive firms reported more frequent barriers to innovation. Iammarino et al. (2009) studied Italian firms and focused on whether the perception of barriers to innovation varied among types of firms and regions. Similarly, they concluded there is a positive relationship between a firm's perception of innovation barriers and their propensity to innovate. Galia and Legros (2004) investigated French manufacturing firms and found a positive association between the propensity to or intensity of innovation and the likelihood of perceiving the barriers to innovation as very relevant. In a study in Turkey, Demirbas (2010) found that innovative entrepreneurs perceived barriers to innovation to be higher. Also, in a study of Portuguese manufacturing firms, Silva, Leitao, and Raposo (2007) showed that firms that innovate are those that perceive more barriers to innovation.

The main focus of the empirical literature on innovation barriers has been on the lack of available financing or cost factors (Hall, 2002). However, while financial resources are necessary to carry out innovation activities, there are other factors that may significantly hinder innovation that are related to knowledge, market, and the policy and regulatory environment. These factors are categorized as internal and external and can be revealed and deterring barriers (Stanislawsky and Olczak, 2010; Madrid-Guijarro, Garcia, and Van Auken, 2009; Hadjimanolis, 2003; D'Este et al., 2008; Blanchard et al., 2013; Pellegrino and Savona, 2013; Piatier, 1984). Internal barriers emerge and create resistance within the firm. Examples include issues of firm management and internal policies, organizational culture, employee competence, and lack of internal financing. On the other hand, external barriers come about due to the environment in which the firm operates and arise when the firm interacts with other firms or institutions. Prevailing market conditions are also a factor. Firms have no control over external barriers, which include limited government support, lack of external financing, deficiency of technology and technological knowledge, difficulty in accessing knowledge, paucity of knowledge about market opportunities, limited opportunity for innovation cooperation, inadequately skilled and knowledgeable labor force, and lack of sufficient demand.

The empirical literature uses data from surveys to look at the impact of barriers—largely financial—on the propensity to innovate and the intensity of innovation. Such studies have shown that firms' engagement in innovative activity is significantly reduced or discouraged by barriers to innovation. Savignac (2008) studied French manufacturing firms and illustrated that the likelihood that a firm would carry out innovation activity is significantly reduced by financial barriers. Tiwari, Buse, and Herstatt (2007) studied Dutch firms and found that perceived financial barriers to research and development (R&D) was a significant barrier. In a study of Italian manufacturing small and medium

sized enterprises (SMEs), Mancusi and Vezzulli (2010) provided empirical support for the theory that financing is a significant barrier to innovation, especially for young and small firms. In a similar study, Silva et al. (2007) provided empirical evidence that high innovation costs—along with a lack of qualified personnel and lack of customers' responsiveness to new products—had a negative and significant effect on innovation propensity.

Empirical studies also examine whether small firms are more likely to experience and are more negatively affected by innovation barriers. In a study of Canadian firms, including SMEs, Tourigny and Le (2004) found that firm characteristics, in particular firm size, affected the propensity to innovate. Hadjimanolis (1999), in a study of SMEs in Cyprus, showed that the most important internal barriers were the lack of time, inadequacy of R&D activities, design and testing within the company, and inadequate financial resources, while the most challenging external barriers were ease of copying the innovation, government bureaucracy, lack of government support, lack of qualified human resources, government policies, and bank lending. Madrid-Guijarro et al. (2009) found that the barriers to innovation that Spanish SMEs faced were the external environment, human resources, and financial position. Mohnen and Rosa (2001), Hyytinen and Toivanen (2005), and Iammarino et al. (2009) found that small firms faced significant financial barriers to innovation. Pihkala, Ylinenpaa, and Vesalainen (2002), using a sample of European SMEs, empirically illustrated that the barriers to innovation were not equally distributed among firms, but differed based on age, size, type of industry, and the innovativeness of the firm. Other studies have shown that large firms are more likely to be negatively affected by innovation barriers. Baldwin and Lin (2002) claimed that large firms are more likely to report barriers to innovation than small firms due to differences in technology advancement. Baldwin and Lin (2002) and Tourigny and Le (2004) found that large firms were more likely to report barriers related to costs and organization of innovation than small firms.

Studies have considered technology intensity as having an impact on innovation barriers (e.g., Dosi, 1988). There are extensive differences in intensity of innovation since firms in different industries face different barriers (Baldwin and Lin, 2002; Tourigny and Le, 2004). For instance, firms in low and medium-low technology industries are less likely to face barriers than those in high and medium-high technology industries. Studies have also examined the perception of innovation between domestic and foreign firms. Iammarino et al. (2009) studied foreign- and Italian-owned multinational corporations operating in northern and central Italy and found that foreign-owned firms were more aware of innovation barriers. Baldwin and Lin (2002) and Mohnen and Rosa (2001) found that competition increased innovation barriers. Mohnen and Rosa (2001) stated that firms that had less competition considered innovation barriers irrelevant. Baldwin and Lin (2002) and Tourigny and Le (2004) claimed that the more competition a firm faced, the higher the likelihood that it faced cost, labor, and other problems. The barriers to innovation are therefore strongest when competition is at its highest level.

Innovation barriers are likely to exert different effects during different phases of the innovation process. For instance, lack of finance might deter the initial decision to invest in innovation activities, while lack of demand might lower incentives to launch a new product or enter a new market even though adequate financing is available. Therefore, providing evidence about which of these factors affects each of the different phases of firms' innovative processes has very relevant policy implications. There are very few empirical studies about barriers to innovation for each phase of the innovation cycle (Segarra-Blasco, Garcia-Quevedo, and Teruel-Carrizosa, 2008; Coad, Pellegrino, and Savona, 2013; Pellegrino and Savona, 2013). These studies used a modified version of the structural recursive model originally proposed by Crépon, Duguet, and Mairesse (1998), or the CDM model, and later extended in the literature (Griffith et al., 2006; Crespi and Zuniga, 2012). The model takes into account the decision by firms to invest in innovation

activities and how much to invest, along with other inputs related to labor productivity, in creating a knowledge production function from which the output production function is then created.

Data and Methodology

This chapter uses the PROTEqIN survey completed by Compete Caribbean in 2014. The survey was conducted in 13 Caribbean countries: Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, St. Kitts and Nevis, Saint Lucia, St. Vincent and the Grenadines, Suriname, and Trinidad and Tobago. The data was used to identify innovation barriers related to financing and cost, knowledge, market, and policy and regulation faced by Caribbean firms.

The methodology was based on pioneering work in innovation and productivity by Crépon et al. (1998), later extended by Griffith et al. (2006), OECD (2009), and Crespi and Zuniga (2012). The CDM model takes into account the decision by firms to invest in innovation activities, along with other inputs related to labor productivity, to create a knowledge production function from which the output production function is then created. A firm's innovation decision includes any action that aims to increase its knowledge, such as new concepts, ideas, processes, and methods. This includes R&D and other expenditures, such as product design, marketing, staff training, new machinery, and patents and other trademark licensing.

Unlike the majority of studies based on the CDM model that consider the effect of classic determinants of innovation on productivity at various stages in a firm's innovation cycle, this chapter focuses on the role of different types of obstacles to innovation as the potential cause of low levels of productivity rather than on the effect of classic determinants of innovation on productivity at various stages in a firm's innovation cycle. The main explanatory variables used in this chapter account for the presence of obstacles to innovation related to financing and cost, market, knowledge, and policy and regulation, which have been outlined as key hindrances to innovation in past studies (D'Este et al., 2008, 2012; Savignac, 2008; Pellegrino and Savona, 2013). To reduce selection bias, the study for this chapter identified the relevant sample of innovators and potential innovators by excluding those firms that stated they are not willing to innovate and therefore do not engage in any innovation activity for reasons other than obstacles.

The importance of firm heterogeneity, such as size, in explaining innovation activities and the need to control for their effects on firm performance was also taken into account (Hall and Mairesse, 2006; Mairesse and Mohnen, 2010). The study also included variables to account for sector and country effects. A weakness of the model that must be acknowledged is that, inherently, the interpretation of results in terms of causality is fairly limited since external shocks are not considered. Ideally, the occurrence of an exogenous shock to innovation barriers would allow causality to be identified confidently; however, no such shocks occurred during the sample period.

The Filtering Process: Sample Selection of Innovative and Potentially Innovative Firms

Taking a lead from D'Este et al. (2008), Mohnen et al. (2008), and Savignac (2008), the study sample included innovative and non-innovative firms willing to innovate, and filtered out firms unwilling to innovate that, therefore, did not engage in innovation for reasons unrelated to innovation barriers. Firms that do not want to innovate, and therefore do not encounter barriers to innovation, are highly likely to report barriers as not important, which could lead to a spurious positive impact of innovation barriers on a firm's propensity to innovate. Thus, the study overcame the sample selection bias that arises when innovation surveys ask all firms interviewed, regardless of their willingness to innovate, about obstacles to innovation by filtering out firms uninterested in innovating. Three categories of firms were identified:

1. **Innovative firms** carry out innovation activities and rank barriers as important.

2. **Potentially innovative firms** report that they are willing to innovate or that they experience some sort of barrier to starting to innovate.
3. **Firms not willing to innovate** do not carry out any innovation activities and thus do not experience any barriers to innovation.

Information in the survey made it possible to identify these groups. Though the PROTEqIN survey began by questioning all firms about their innovation activities, not all firms would have been innovative: some may have undertaken innovation unsuccessfully and others may not have been interested in innovation. A firm might have decided that it did not need to innovate because of a lack of interest or because it had innovated recently; therefore, in principle, such a firm did not experience innovation barriers. Nevertheless, all firms surveyed were required to answer questions about the impact of innovation barriers on their innovation activities.

A firm was defined as an innovator if it introduced a new or significantly improved product (either a good or service) or any new or significantly improved process for producing or supplying products. If the firm did not introduce a new or significantly improved product or process over the period, it was classified as a non-innovator. To differentiate between potentially innovative firms and firms not willing to innovate, the responses to questions regarding barriers to innovation were examined. Firms that ranked barriers as important were classified as potentially innovative, while those that viewed barriers as not important were classified as firms not willing to innovate. The relevant sample therefore included innovative and potentially innovative firms and excluded firms not willing to innovate to correctly estimate the sign and intensity of the relationship between innovation and a firm's assessment of barriers to innovation. The questionnaire included 19 barriers to innovation classified into four categories: financing and cost, market, knowledge, and policy and regulation. The extent to which a firm experienced any category of barrier was based on whether the firm experienced at least one of the innovation barriers included within each category.

The Econometric Model

The relationship between innovation and productivity is complex, beginning with a firm's initial decision to innovate and how much to spend, followed by its innovative output and the impact on productivity. A firm faces various obstacles related to financing and cost, market, knowledge, and policy and regulation throughout this process. To take this into account, this chapter adapted the CDM model to the role played by barriers to innovation. CDM is a three step structural model that establishes the relationship among innovative input, innovative output, and productivity. First, a firm decides whether to invest in innovation and the amount to invest. Second, innovation output is treated as a function of innovation input and other factors in the knowledge production function. Third, an augmented Cobb-Douglas production function establishes the effect of innovative output on productivity. The adapted model made it possible to investigate the role of different obstacles to innovation at each of these three stages.

The CDM model is a system of five equations that link a firm's R&D expenditures to its innovation output, and its innovation output to productivity. The equations included four variables that identify the presence of obstacles to innovation related to financing and cost, market, knowledge, and policy and regulation.

The model was estimated in three steps. In the first step, a two-equation system as used to (1) model the firm's innovation decision and (2) the size of the innovation effort, while taking into account innovation barriers. Both equations used a generalized Tobit model and estimated using maximum likelihood estimation. Let $i = 1,\ldots,N$ represent an index of firms. The first equation of the model accounted for the firm's innovative effort IEi^*:

$$IE_i^* = z_i' \beta + e_i \qquad (1)$$

where IE_i^* is a latent variable for unobserved but desired expenditures, and z_i is a vector of determinants of a firm's innovation decision, including innovation barriers, β is a vector of parameters, and e_i

is the error term. Equation 2 is an indicator function that takes the value 1 if the firm carried out innovative activity. Equation 2 also uses various explanatory variables that affect a firm's decision to undertake innovation activities, including firm size; whether the firm received public funding; whether the firm had an R&D department; whether the firm faced competition; ownership; patent protection; and whether it was an exporting firm, together with innovation barriers related to financing and cost, market, knowledge, and policy and regulation barriers to innovation, as well as country- and industry- specific effects.

$$ID_i = 1 \text{ if } ID_i^* = w_i'\alpha + e_i > 0$$
$$0 \text{ if } ID_i^* = w_i'\alpha + e_i c \qquad (2)$$

where *ID* is an observable binary endogenous variable equal to 1 if the firm invested in innovation activities and 0 if it did not, ID^* is a latent indicator variable whereby the firm incurred innovation expenditures if these were above a certain threshold level *c*, which is the minimum innovation expenditure and was 0 in our case, *w* is a vector of variables that influenced the innovation investment decision, including the variables related to innovation barriers, α is a vector of parameters of interest, and *e* is the error term.

Equation 3 was the innovation intensity equation. Conditional on firm *i* engaging in innovation activities, the amount of resources invested in innovation *IE* activities was observed:

$$IE_i = IE_i^* = z_i' \beta + \varepsilon i \text{ if } ID_i = 1$$
$$0 \text{ if } ID_i = 0 \qquad (3)$$

where *z'* is a set of determinants of innovation expenditure and ε is the error term. Other determinants in the innovation expenditure equation are dummies for exporting, patent protection, cooperation on R&D, whether the firm faced competition, whether the firm had an R&D department, and public financial support, as well as the dummy variables for innovation barriers related to financing and cost, market, knowledge, and policy and regulation, together with country- and industry-specific effects.

Assuming the error terms *e* and ε were bivariate normal with a zero mean, variances $\sigma_\varepsilon^2 = 1$ and σ_e^2 and correlation coefficient $\rho_{\varepsilon e}$, the system of Equations 1 and 2 are then estimated as a generalized Tobit model by maximum likelihood.

The second step in the estimation exercise links innovation activities to innovation output with an innovation/knowledge production function using the predicted values of the innovation effort from step one as one of the dependent variables along with the various innovation barriers.

$$TI_i = IE_i^*\gamma + x_i' \delta + u_i \qquad (4)$$

where *TI* is the observed 0–1 variable indicating knowledge outputs by firm innovation activities (introduction of a new product or process at the firm level takes a value of 1 and 0 otherwise), and where the latent innovation effort, *IE*, from step one enters as an explanatory variable, *x* is a vector of other determinants of knowledge production, γ and δ are vectors of parameters of interest, and *u* is an error term. The explanatory variables are firm size and a dummy variable for exporting and ownership, patent protection, and the innovation barrier dummy variables together with country- and industry-specific effects. Equation 4 is estimated using a Probit model with the predicted value of (log) innovation expenditure as the main explanatory variable rather than reporting innovation efforts. Importantly, this corrects for potential endogeneity in the knowledge production equation.

Equation 5 is the output production function/productivity equation, which links a firm's innovation output to productivity by including it as an input in an augmented Cobb-Douglas production function along with innovation barriers. As a third step in the estimation exercise, this equation is estimated using the predicted values from the Probit model in the second step since they account for endogeneity of the innovation output variables. The assumption was that a firm's productivity depends on its own investment and external knowledge. Firms produce output using constant returns to scale with labor, capital, and knowledge inputs as follows:

$$y_i = \theta_i k_i + \theta_2 TI_i + v_i \quad (5)$$

where output y is labor productivity (log of sales per worker), k is the log of physical capital per worker (using physical investment per worker as a proxy), TI enters as an explanatory variable that refers to the impact of technological innovation on productivity levels predicted from equation (3), and v is the error term. The independent variables in the production function include the log of physical capital per employee, predicted values of product and process innovation dummies from the second step, firm size, and variables for innovation barriers, as well as country- and industry-specific effects.

Results

Descriptive Analysis

The data show that, based on three firm categories, 26 percent of firms surveyed were innovators (started and completed innovation activities and ranked barriers as important), 59 percent were potential innovators (did not start or started but did not successfully complete innovative activity and ranked barriers as important), and 15 percent were non-innovators (did not undertake any innovation activity and ranked barriers as not important). Thus, while the proportion of firms that were innovators was relatively small, there was a large percentage of potential innovators in the Caribbean. Government policy aimed at reducing innovation barriers may therefore increase the number of innovative firms in the region, thereby stimulating increased innovation and productivity.

The study also investigated the extent to which differences among the three firm categories existed across the different Caribbean islands to get an idea of the distribution of innovators, potential innovators, and non-innovators across the region. Table 2.1 shows that Trinidad and Tobago (16 percent), Suriname (15 percent), Guyana (14 percent), and Jamaica (10 percent) had the highest percentage of innovative firms. Antigua and Barbuda,

TABLE 2.1. Innovators, Potential Innovators, and Non-innovators, by Country

	Innovative firms		Potentially innovative firms		Non-innovative firms	
Country	#	%	#	%	#	%
Antigua and Barbuda	22	4	74	6	35	12
Belize	20	4	97	8	5	2
Barbados	39	8	79	7	5	1
Bahamas, The	28	5	72	6	27	9
Dominica	18	4	75	7	33	11
Grenada	22	4	81	7	26	9
Guyana	69	14	40	3	11	4
Jamaica	50	10	186	16	6	2
Saint Lucia	24	5	80	7	24	8
St. Kitts and Nevis	23	4	78	7	24	8
St. Vincent and the Grenadines	35	7	69	6	29	10
Suriname	76	15	39	3	5	1
Trinidad and Tobago	80	16	190	16	70	23

Source: Authors' elaboration based on PROTEqIN data.

Belize, Dominica, Grenada, and St. Kitts and Nevis had the lowest percentage of innovative firms at 4 percent. In terms of potential innovators, Trinidad and Tobago and Jamaica each had 16 percent of such firms, followed by Belize with 8 percent. For non-innovators, Trinidad and Tobago had the largest proportion (23 percent), followed by Antigua and Barbuda (12 percent), and Dominica (11 percent).

Table 2.2 provides the main firm characteristics of the three groups to investigate and compare differences among innovators, potential innovators, and non-innovators. Firm size was measured by number of employees, and innovators were significantly larger than potential innovators and non-innovators. Table 2.2 shows that 22 percent of the innovators were large firms compared to 11 percent of potential innovators and 10 percent of

TABLE 2.2. Firm Characteristics

	Innovative firms		Potentially innovative firms		Non-innovative firms	
Firm characteristics	**#**	**%**	**#**	**%**	**#**	**%**
Size (number of employees)						
Small (< 20 employees)	183	36	595	51	159	53
Medium (≥ 20 and < 100 employees)	210	42	436	38	111	37
Large (≥ 100 employees)	113	22	129	11	30	10
Ownership						
Local	412	81	986	85	257	86
Foreign	94	19	174	15	43	14
Exporter/non-exporter						
Exporter	162	32	199	17	52	17
Non-exporter	344	68	961	83	248	83
Industry						
Manufacturing	291	58	308	27	61	20
Other manufacturing	67	13	96	8	11	4
Food	106	21	74	6	16	5
Textiles	1	0	5	0	—	—
Garments	12	2	26	2	3	1
Chemicals	27	5	20	2	4	1
Plastics and rubber	8	2	10	1	—	—
Non-metallic mineral products	17	3	31	3	1	0
Basic metals	4	1	14	1	9	3
Fabricated metal products	21	4	8	1	6	2
Machinery and equipment	20	4	19	2	6	2
Electronics	8	2	5	0	5	2

(continued on next page)

TABLE 2.2. Firm Characteristics *(continued)*

	Innovative firms		Potentially innovative firms		Non-innovative firms	
Firm characteristics	**#**	**%**	**#**	**%**	**#**	**%**
Services	215	42	852	73	239	80
Construction	25	5	82	7	29	10
Services for motor vehicles	6	1	64	6	8	3
Wholesale	19	4	61	5	15	5
Retail	85	17	296	26	85	28
Hotel and restaurants	44	9	233	20	62	21
Transport	26	5	93	8	35	12
Information technology	10	2	23	2	5	1
Part of a Larger Firm						
Yes	120	24	175	15	41	14
No	386	76	985	85	259	86
Gender of Top Management						
Male	416	82	885	76	234	88
Female	90	18	275	24	66	12
Competitors						
Registered/formal firms						
None	10	2	5	0.4	1	0
1	4	1	15	1.3	4	1
2–5	107	21	224	19	62	21
>5	385	76	916	79	233	78
Unregistered/informal firms						
Yes	278	55	699	60	168	56
No	228	45	461	40	132	44

Source: Authors' elaboration based on PROTEqIN data.

non-innovators. Non-innovators had the largest share of local firms (86 percent local; 14 percent foreign), followed by potential innovators (85 percent; 15 percent) and innovators (81 percent; 19 percent). Innovators had the largest share of exporters at 32 percent, while potential innovators and non-innovators both had 17 percent of the firms that were exporters. Innovators had the highest number of firms (24 percent) that were part of a larger organization, followed by potential innovators (15 percent) and non-innovators (14 percent). Potential innovators had the largest percentage of female managers (24 percent), followed by innovators (18 percent) and non-innovators (12 percent).

A larger proportion of innovators were in manufacturing than in services (58 percent versus

42 percent). Potential innovators (27 percent manufacturing; 73 percent services) and non-innovators (20 percent manufacturing; 80 percent services) had a higher number of firms in the services sector. Thus, in the Caribbean, innovators were more likely to be in the manufacturing sector, while potential innovators and non-innovators were more likely to be in the services sector. Looking at the disaggregated sector profile, innovators had the largest number of firms in food (21 percent) and retail (17 percent), while potential innovators and non-innovators had the largest number of firms in the retail sector (26 percent and 28 percent, respectively) followed by the hotel and restaurant sector (20 percent and 21 percent, respectively). Interestingly, innovators (13 percent) and potential innovators (8 percent) had a higher proportion of firms in "other manufacturing" compared to non-innovators (4 percent), as well as in the knowledge-intensive information technology sector (2 percent for innovators and potential innovators, and 1 percent for non-innovators).

For the level of competition from registered firms, all three groups reported that they face a relatively high level of competition. For innovators, 76 percent stated that they face more than five competitors (the largest competitor category in the survey), while the corresponding figures for potential innovators and non-innovators were 79 percent and 78 percent, respectively. With regard to informal competition, a significant portion of firms reported that they faced such competition. Potential innovators had the largest share of firms reporting that they faced competition from unregistered firms (60 percent), followed by non-innovators (56 percent) and innovators (55 percent).

Table 2.3 details the items included within each of the four innovation barrier categories (financing and cost, knowledge, market, and policy and regulation) to examine how the different categories affected innovative versus potentially innovative firms. A barrier item was ranked as important if the firm assessed it as a "major obstacle" or "very severe obstacle" in the survey. The results are presented for innovative and potentially innovative firms only since non-innovative firms would have ranked these barriers as not important in the survey.

Table 2.3 provides evidence of an important characteristic of the impact of barriers on innovation that is consistent in the literature: potentially innovative firms in the Caribbean experience higher barriers to innovation than innovative firms regardless of the type and barrier category considered. Specifically, the barriers that affected potential innovators much more than innovators were: direct public funding for innovation (financing and cost); flexibility and openness of other companies in the sector to collaborative approaches (knowledge); time to market (market); and protection against copycats (policy and regulation). Therefore, firms in the region that have not yet innovated may be more likely to be affected by innovation barriers, perhaps even more than innovative firms. This result underscores the importance of investigating potentially innovative and innovative firms when studying innovation barriers. Moreover, when considering both groups, researchers should account for deterring barriers, which discourage firms from innovation activities and are more likely faced by potential innovators, and revealed barriers, which are faced during innovation activities and are more likely faced by innovators (Arundel, 1997; Baldwin and Lin, 2002; Iammarino et al., 2009).

Table 2.3 also provides evidence of another well-established finding in the literature: financing and cost barriers are the most significant barriers faced by firms, whether they are innovative or potentially innovative. Knowledge factors are the next most significant innovation barriers faced by Caribbean firms, followed by market barriers, and policy and regulation barriers, which are the least experienced obstacles. Direct public funding was listed by the largest number of firms as an important barrier (43 percent of innovators and 54 percent of potential innovators) compared to any other barrier item. Additionally, the PROTEqIN survey specifically asked firms to identify any other innovation obstacles not stated in the questionnaire that are significant hindrances

TABLE 2.3. Proportion of Firms Assessing Barriers as Important

	Innovator		Potential innovator	
Barriers	**#**	**%**	**#**	**%**
Financing and cost				
Level of available financial resources	209	41	526	45
Direct public funding for innovation	219	43	625	54
Knowledge				
Qualification of employees	169	33	452	39
Technical uncertainties	135	27	412	36
Level of information about available technologies	98	19	286	25
Level of information about new trends in the market	155	31	455	39
Linkages with public universities and tertiary institutions	177	35	466	40
Technical capacity in key institution responsible for innovation promotion	100	20	282	24
Flexibility/openness of laboratories/research centers for collaborative approaches	199	39	523	45
Flexibility/openness of other companies in the sector for collaborative approaches	213	42	615	53
Market				
Client flexibility and openness to new goods or services	61	12	180	16
Time to market	195	39	583	50
Policy and regulation				
Requirements to comply with international standards	141	28	414	36
Current organizational and managerial culture	147	29	399	34
Internal remuneration policy and incentive structure	59	12	200	17
Protection against copycats	208	41	575	50
Investment and policy framework to foster innovation	109	22	301	26
Degree of self-confidence for innovation	104	21	267	23

Source: Author's compilation based on PROTEqIN data.

to innovation. Funding opportunities for innovation was identified as a severe barrier, as well as human capacity. The least significant innovation obstacles faced by Caribbean firms identified in the survey were client flexibility and openness to new goods or services (innovators 12 percent and potential innovators 16 percent) and the firm's internal remuneration policy and incentive structure (innovators 12 percent and potential innovators 17 percent).

Econometric Results

The Decision to Invest in Innovation and the Intensity of Innovation Expenditures

The descriptive analysis above shows that a significant proportion of firms surveyed are non-innovators (15 percent)—they did not carry out any innovation activities and ranked innovation barriers as not important (likely not encountering any). Including these firms in the analysis could lead to a

spurious positive impact between the propensity to innovate and the existence of innovation barriers. Hence, to obtain reliable results on innovation barriers, non-innovators were excluded from the regression sample, including only potential innovators and innovators. The appendix provides the list of variables used in the econometric analyses and their definition.

Table 2.4 presents the results of the estimation of the Heckman equation with a selection model for a firm's engagement in innovation activities and the outcome equation for the intensity of innovation expenditures as the log of innovation expenditure per employee. The reported estimates are the marginal effects. A firm's decision to carry out innovation activities was modelled in that it depends on the traditional determinants of the decision to innovate and on the existence of financing and cost, knowledge, market, and policy and regulation barriers to innovation. Four dummy variables were used, one for each barrier category. They take a value of 1 if the firm ranked the barrier as important in negatively affecting innovation.

Table 2.4 shows that factors that increased a firm's likelihood of engaging in innovation activities include firm size, whether the firm exported, whether the firm had an R&D department, whether the firm faced competition from formal and informal firms, and patent protection, while foreign ownership did not increase the likelihood that a firm would decide to innovate. Thus, larger firms, firms that have patents, firms that have an R&D department, and firms that face competition are more likely to carry out innovation activities. All four barrier categories made the decision to innovate difficult since all the coefficients were negative; however, only the cost and market coefficients were significant. These results suggest that, in general, barriers to innovation limit a firm's decision to innovate. Moreover, the significant negative results for innovative and potentially innovative firms highlight the importance of revealed and deterring barriers, as shown in the literature by D'Este et al. (2008, 2012), Savignac (2008), and Mohnen et al. (2008). Thus potentially innovative firms in the Caribbean also rank barriers as important and are negatively affected by them.

Examining the results of the determinants of logged innovation expenditure per employee

TABLE 2.4. Probability of Investing in Innovation (ID) and Intensity of Innovation Expenditure per Employee (IE)

ID (probability of investing in innovation IE>0)		
Exporting	0.032**	(.012)
Foreign ownership	0.005	(.010)
Patent protection	0.242***	(.053)
R&D department	0.219***	(.037)
Competition	0.022***	(.007)
Size	0.015***	(.030)
Financing and cost barriers	−0.015**	(.007)
Knowledge barriers	−0.011	(.008)
Market barriers	−0.023***	(.007)
Policy and regulation barriers	–0.005	(.007)
IE (log of innovation expenditure per employee)		
Exporting	0.240***	(.087)
Foreign ownership	0.041	(.072)
Patent protection	1.684***	(.353)
Co-operation in R&D	0.000	(.008)
Public Financial Support	−0.012	(.007)
R&D department	1.573***	(.262)
Competition	0.169***	(.054)
Financing and cost barriers	−0.099*	(.052)
Knowledge barriers	−0.082	(.058)
Market barriers	−0.168***	(.052)
Policy and regulations barriers	−0.036	(.052)
Observations	1,666	
Censored observations	1,297	
Wald test	133.34***	
Wald test of independence ()	36.73***	
Log pseudo likelihood	−1,176.094	

Source: Authors.
Notes: Coefficients reported are marginal effects. *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

reveals that whether the firm exported, whether the firm had an R&D department, whether the firm faced competition, and patent protection appear to predict innovation expenditure, while foreign ownership, public financial assistance, and cooperation on innovation were not predictive. All four barrier categories negatively affected innovation expenditures, although once again, only the cost and market coefficients were significant. These results suggest that, in general, barriers to innovation related to financing and cost, knowledge, market, and policy and regulation limit a firm's innovation expenditures. Further, since these barriers affect the decision to engage in innovation and the intensity, they can be considered both revealed (faced during innovation activities) and deterring barriers (faced at the start of innovation activities).

TABLE 2.5. Probability of Technological Innovation *(TI: Introduction of Product or Process Innovation)*

IE_p (predicted innovation expenditure per employee)	0.499***	(.046)
Size	0.043***	(.013)
Exporting	−0.039	(.036)
Foreign ownership	0.054	(.058)
Financing and cost barriers	−0.459***	(.027)
Knowledge barriers	−0.254***	(.054)
Market barriers	0.055	(.046)
Policy and regulation barriers	−0.345***	(.037)
Observations	1,666	
Wald	483.60***	
Log pseudo likelihood	−468.084	
Pseudo R^2	0.542	
Observed probability	0.304	
Predicted probability (values at means)	0.212	

Source: Authors.
Notes: Coefficients reported are marginal effects. Robust standard errors in parentheses. *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

The Impact of Innovation Investment on the Probability of Technological Innovation

Table 2.5 illustrates the results for the estimation of the knowledge production function for a product and process innovation dummy variable that was used as the technological innovation output variable. The coefficients reported are the marginal effects.

The results illustrate that Caribbean firms that spent more on innovation per employee were more likely to introduce product or process innovation. More specifically, as the coefficient on the predicted innovation expenditure shows, a unit increase in logged innovation expenditure per employee increased the probability of technological innovation by about 50 percent. In addition, firm size increased the probability of technological innovation. More specifically, as the size of the firm increased, the probability of technological innovation rose by about 4 percentage points. The innovation barriers related to financing and cost, knowledge, and policy and regulation were negative and significant and therefore reduced the probability of a product or process innovation. The cost barrier dummy variable coefficient was the largest. A firm facing cost obstacles was 46 percent less likely to introduce a product or process innovation. Knowledge barriers reduced product and process innovation by 25 percent, while the corresponding figure for policy and regulation barriers was 34 percent. The results, in keeping with the literature, suggest that cost factors appear to be the most relevant constraint facing firm innovation (Hall, 2002; Savignac, 2008). However, the findings also highlight that, while financial factors are significant hindrances, other factors also play a role.

The Impact of Innovation on Productivity

Finally, Table 2.6 shows the results of the productivity equation, where the coefficients were reported as elasticities or semi-elasticities since the dependent variable was the log of sales per employee. The study found that innovation expenditure per employee had a positive but not significant impact on labor productivity. Of note, none of the four

innovation barriers had a significant impact on labor productivity.

Conclusions

A large number of firms face numerous obstacles to innovation. These barriers hinder progress for both innovative and potentially innovative firms. Revealed barriers impede an innovative firm's achievement of innovation and constrain innovation success, while deterring barriers prevent a potentially innovative firm from engaging in innovation activities. These barriers are related to financing and cost, market, knowledge, and policy and regulation factors. This chapter studied such innovation barriers and their impact on innovation and productivity for innovative and potentially innovative firms in 13 Caribbean SIDS using Compete Caribbean's PROTEqIN survey, which was completed in 2014.

The PROTEqIN data indicated that innovation is quite low in the Caribbean, as only 26 percent of firms surveyed engaged in any sort of innovative activity. On a more positive note, however, the data also showed that 59 percent of all firms surveyed are potentially innovative. These firms are willing to innovate but may not have been successful in doing so because they face various barriers. Also, the portion of non-innovative firms in the region was quite low at 15 percent. Government policy can therefore play a key role in helping to reduce innovation failures and alleviate barriers to innovation by designing and implementing appropriate policies and incentives for firms to engage in innovative activity and reduce market failures to innovation in the Caribbean. This could increase the number of innovative firms and the level of innovation, thereby leading to increased productivity and growth and development in the region. It is also important for a firm's innovation strategy to take into account these obstacles, since recognizing the barriers may increase the chances of success and the economic pay-off from innovation activities.

The study found that potentially innovative firms in the Caribbean experienced higher barriers to innovation than innovative firms regardless of the type and category of barrier. Specifically, the barriers that affected potential innovators much more than innovators were: direct public funding for innovation (financing and cost); flexibility and openness of other companies in the sector to collaborative approaches (knowledge); time to market (market); and protection against copycats (policy and regulation). Therefore, firms in the region that have not yet innovated are more likely to experience innovation barriers and, perhaps, even more so than innovative firms.

The descriptive findings also showed that financing and cost were the most significant barriers faced by Caribbean firms whether they were innovative or potentially innovative. Knowledge factors were the next most common innovation barrier followed by market barriers, with policy and regulation barriers being the obstacles experienced least often. Direct public funding was most often listed as an important barrier (43 percent of innovators and 54 percent of potential innovators). Additionally, the PROTEqIN survey specifically

TABLE 2.6. The Impact of Innovation on Labor Productivity *(Y: log sales per employee)*

IE_p (predicted innovation expenditure per employee)	0.092	(.116)
Size	0.109***	(.047)
Capital per employee	0.376***	(.054)
Financing and cost barriers	−0.103	(.099)
Knowledge barriers	0.085	(.134)
Market barriers	0.107	(.155)
Policy and regulation barriers	−0.020	(.102)
Observations	1,666	
Wald test	577.98***	
R^2	0.140	

Source: Authors.
Notes: Bootstrapped standard errors in parentheses (100 replications). The variable used as a proxy for physical capital is investment made during the period considered the stock of physical capital. *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

asked firms to identify any barriers to innovation not stated in the questionnaire that were significant hindrances. Funding opportunities and human capacity were identified as severe barriers. The least significant innovation barriers identified in the survey were client flexibility and openness to new goods or services (innovators 12 percent and potential innovators 16 percent) and internal remuneration policy and incentive structure (innovators 12 percent and potential innovators 17 percent). The findings of the econometric model illustrated that firms that export, firms with an R&D department, firms that face competition, firms that have patents, and larger firms are more likely to decide to carry out innovation activities.

Financing and cost, knowledge, market, and policy and regulation barriers make the decision to innovate difficult since all the coefficients were negative, although only the cost and market coefficients were significant. Therefore, this study found that, in general, barriers to innovation affect both innovative and potentially innovative firms in the decision to innovate. The results also showed that exporting, competition, and patent protection affect innovation expenditures, while foreign ownership, public financial assistance, and cooperation on innovation have no significant effect. Furthermore, the findings suggest that, in general, all four barrier categories negatively affect firm innovation expenditures, with the cost and market coefficients being significant.

The study found that Caribbean firms that spend more on innovation are more likely to introduce a product or process innovation. More specifically, a unit increase in logged innovation expenditure per employee increased the probability of technological innovation by about 50 percent. In addition, exporting and firm size increased the probability of technological innovation. More importantly, cost, knowledge, and policy factors reduced the probability of a product or process innovation. The cost barrier dummy variable coefficient was the largest, suggesting that cost barriers have the largest negative impact on innovation in the region. A firm facing cost obstacles was 46 percent less likely to introduce a product or process innovation. Knowledge barriers reduced product and process innovation by 25 percent, while the corresponding figure for policy barriers was 34 percent. Moreover, innovation expenditures had a positive but not significant impact on labor productivity. Lastly, the four innovation barrier variables did not appear to have a significant impact on labor productivity.

References

Arundel, A. 1997. "Enterprise Strategies and Barriers to Innovation." In A. Arundel and R. Garrelfs, eds., *Innovation Measurement and Policies*, pp. 101–108. EIMS Publication. Luxembourg: European Commission.

Baldwin, J., and Z. Lin. 2002. "Impediments to Advanced Technology Adoption for Canadian Manufacturers." *Research Policy* 31(1):1–18.

Blanchard, P., J.-P. Huiban, A. Musolesi, and P. Sevestre. 2013. "Where There Is a Will, There Is a Way? Assessing the Impact of Obstacles to Innovation. Industrial and Corporate Change." *Industrial and Corporate Change* 22(3):679–710.

Coad, A., G. Pellegrino, and M. Savona. 2013. "The Long Good-Bye: A Longitudinal Analysis of Barriers to Innovation." Paper presented at the 4th European Conference on Corporate R&D and Innovation CONCORDi-2013, September 26–27, 2013, in Seville (Spain).

Crépon, B., E. Duguet, and J. Mairesse. 1998. "Research, Innovation and Productivity: An Econometric Analysis at the Firm level." *Economics of Innovation and New Technology* 7(2):115–58.

Crespi, G., and P. Zuniga. 2012. "Innovation and Productivity: Evidence from Six Latin American Countries." *World Development* 40(2):273–90.

D'Este, P., S. Iammarino, M. Savona, and N. von Tunzelmann. 2008. "Barriers to Innovation: Evidence from the UK Community Innovation Survey." SPRU Electronic Working Paper Series. Brighton, UK: Science Policy Research Unit, University of Sussex.

——— . 2012. "What Hampers Innovation? Revealed Barriers versus Deterring Barriers." *Research Policy* 41:482–8.

Daude, C., and E. Fernandez-Arias. 2010. "The Importance of Ideas: Innovation and Productivity in Latin America." In C. Pages, ed., *The Age of Productivity: Transforming Economies From the Bottom Up,* Part VIII, Ch. 1. Washington, DC: Palgrave-Macmillan.

Demirbas, D. 2010. "How Do Entrepreneurs Perceive Barriers to Innovation? Empirical Evidence from Turkish SMEs." Proceedings of the Oxford Business and Economics Conference, 2010, in Oxford, UK.

Dosi, G. 1988. "Sources, Procedures and Microeconomic Effects of Innovation." *Journal of Economic Literature* 26(3):1120–71.

Freeman, C. 1994. "The Economics of Technical Change." *Cambridge Journal of Economics* 18(5):463–514.

Galia, F., and C. Legros. 2004. "Complementarities between Obstacles to Innovation: Evidence from France." *Research Policy* 33(8):1185–99.

Griffith, R., E. Huergo, J. Mairesse, and B. Peters. 2006. "Innovation and Productivity across Four European Countries." *Oxford Review of Economic Policy* 22(4):483–98.

Griliches, Z.1986. "Productivity, R&D, and Basic Research at the Firm Level in the 1970s." *American Economic Review* 76(1):141–54.

Hadjimanolis, A. 1999. "Barriers to Innovation for SMEs in a Small Less Developed Country (Cyprus)." *Technovation* 19(9):561–70.

——— . 2003. "The Barriers Approach to Innovation." In L. Shavinina, ed., *The International Handbook on Innovation,* pp. 559–73. Oxford: Elsevier Science Ltd.

Hall, B. 2002. "The Financing of Research and Development." *Oxford Review of Economic Policy* 18(1):37–51.

Hall, B., and J. Mairesse. 2006. "Empirical Studies of Innovation in the Knowledge-driven Economy." *Economics of Innovation and New Technology* 15(4–5):289–2.

Hall, R., and C. Jones. 1999. "Why Do Some Countries Produce So Much More Output per Worker than Others?" *The Quarterly Journal of Economics* 114(1):83–116.

Hölzl, W., and K. Friesenbichler. 2010. "High-Growth Firms, Innovation and the Distance to the Frontier." *Economics Bulletin* 30(2):1016–24.

Hyytinen, A., and O. Toivanen. 2005. "Do Financial Constraints Hold Back Innovation and

Growth? Evidence on the Role of Public Policy." *Research Policy* 34(9):1385–403.

Iammarino, S., F. Sanna-Randaccio, and M. Savona. 2009. "The Perception of Obstacles to Innovation. Foreign Multinationals and Domestic Firms in Italy." *Revue d'Economie Industrielle* 125(4):75–104.

IDB. 2010. "Science, Technology and Innovation in Latin America and the Caribbean: A Statistical Compendium of Indicators." Washington, DC: The Inter-American Development Bank.

Lederman, D., J. Messina, S. Pienknagura, and J. Rigolini. 2014. *Latin American Entrepreneurs: Many Firms but Little Innovation*. Washington, DC: The World Bank.

Madrid-Guijarro, A., D. Garcia, and H. Van Auken. 2009. "Barriers to Innovation among Spanish Manufacturing SMEs." *Journal of Small Business Management* 47(4):465–88.

Mairesse, J., and P. Mohnen. 2010. "Using Innovation Surveys for Econometric Analysis." NBER Working Paper 15857. Cambridge, MA: National Bureau of Economic Research.

Mancusi, M., and A. Vezzulli. 2010. "R&D, Innovation, and Liquidity Constraints." KITeS Working Papers 30/2010. Milan: Centre for Knowledge, Internationalization and Technology Studies, Bocconi University.

Mohan, P., E. Strobl, and P. Watson. 2014. "Innovative Activity in the Caribbean: Drivers, Benefits, and Obstacles." Ipag Business School Working Paper Series 2014–595. http://www.ipag.fr/fr/accueil/la-recherche/publications-WP.html.

Mohnen, P., and J. Rosa. 2001. "Barriers to Innovation in Service Industries in Canada." *L'Actualite Economique* 77(2):231–54.

Mohnen, P., F. Palm, S. Van Der Loeff, and A. Tiwari. 2008. "Financial Constraints and Other Obstacles: Are They a Threat to Innovation Activity?" *De Economist* 156(2):201–14.

OECD. 2009. *Innovation in Firms: A Microeconomic Perspective*. Paris, France: Organisation for Economic Co-operation and Development.

Ortiz, E. A., G. Crespi, E. Tacsir, F. Vargas, and P. Zuniga. 2012. "Innovation for Economic Performance: The Case of Latin American and Caribbean Firms." IDB Technical note IDB-TN-494. Washington, DC: Inter-American Development Bank.

Pellegrino, G., and M. Savona. 2013. "Is Money All? Financing versus Knowledge and Demand Constraints to innovation." UNU-MERIT Working paper 2013–029. Maastricht, Netherlands: United Nations University – Maastricht Economic and Social Research Institute on Innovation and Technology.

Piatier, A. 1984. *Barriers to Innovation*. A Study carried out for the Commission of the European Communities, Directorate-General Information Market and Innovation. London and Dover NH: Frances Printer.

Pihkala, T., H. Ylinenpaa, and J. Vesalainen. 2002. "Innovation Barriers among Clusters of European SME." *International Journal of Entrepreneurship and Innovation Management* 2(6):520–36.

Rouvinen, P. 2002. "R&D-Productivity Dynamics: Causality, Lags, and Dry Holes." Journal of Applied Economics 5(1):123–56.

Savignac, F. 2008. "Impact of Financial Constraints on Innovation: What Can Be Learned from a Direct Measure?" *Economics of Innovation and New Technology* 17(6):553–69.

Schumpeter, J. 1939. *Business Cycles: A Theoretical, Historical, and Statistical Analysis of the Capitalist Process*. New York: McGraw-Hill.

Segarra-Blasco, A., J. Garcia-Quevedo, and M. Teruel-Carrizosa. 2008. "Barriers to Innovation and Public Policy in Catalonia." *International Entrepreneur Management Journal* 4(4):431–51.

Silva, M., J. Leitao, and M. Raposo. 2007. "Barriers to Innovation Faced by Manufacturing Firms in Portugal: How to Overcome it?" *International Journal of Business Excellence* 1(1/2):92–105. DOI: http://dx.doi.org/10.1504/IJBEX.2008.017568.

Stanislawski, R., and A. Olczak. 2010. "Innovative Activity in the Small Business Sector of the Textile and Clothing Industry." *Fibres & Textiles in Eastern Europe* 18(1):13–6.

Tiwari, R., S. Buse, and C. Herstatt. 2007. "Innovation via Global Route: Proposing Reference Model for Chances and Challenges of Global Innovation Processes." In *Proceedings of the Second International Conference on Management of Globally Distributed Work*. Bangalore: Indian Institute of Management.

Tourigny, D., and C. Le. 2004. "Impediments to Innovation Faced by Canadian Manufacturing Firms." *Economics of Innovation and New Technology* 13(3):217–50.

Appendix: Variables and Definitions

Technological innovation (TI):	Dummy equal to 1 if the firm introduced a product or process innovation.
Expenditures on innovation activities per employee (IE):	Firm innovation expenditures divided by the number of employees.
Productivity (Y):	Total sales divided by the number of employees.
Firm size (LEM):	Number of employees.
Exporter/non-exporter (EX):	Dummy variable equal to 1 if firm exported.
Foreign ownership (FO):	Dummy variable equal to 1 if foreign capital was above 10 percent.
Patent protection (PA):	Dummy variable equal to 1 if firm had or had filed for a patent.
R&D department (R&D):	Dummy variable equal to 1 if firm had an R&D department.
Competition (COM):	Dummy variable equal to 1 if firm faced competition from formal and informal firms.
Co-operation (CO):	Dummy variable equal to 1 if firm collaborated on innovation.
Public finance (FIN):	Dummy variable equal to 1 if firm received public financing for innovation activities.
Capital per employee (INV):	Firm capital divided by the number of employees.

3

Access to Financing and Innovation in Caribbean Firms

Diego Morris

Innovation is costly and risky, which makes investments in innovation more demanding of adequate and readily available financing (O'Sullivan, 2006). In support of this hypothesis, Aghion and Durlauf (2014) argued that financial development is almost exclusively the conduit through which technological catch up occurs in developing countries. As a consequence, it is plausible that productivity and subsequent growth is restricted when access to financing is constrained. These positions highlight a clear link between innovation and development of the financial sector and, by extension, economic growth at the macroeconomic level.[1] What is not so clear is how this link is reconciled at the micro-level, especially for small open economies like those in the Caribbean.

In particular, from all existing surveys of private sector activity in the Caribbean, access to financing is perceived by managers as one of the top constraints on firm growth. Figure 3.1 clearly illustrates the distance from the frontier score (the best performing economy) in getting access to credit as measured in *Doing Business 2016* (World Bank, 2016). The figure illustrates that, with the exception of Jamaica, which performs very well, and Trinidad and Tobago, which performs relatively well, all other Caribbean economies are far from the frontier. In essence, the figure shows that the best performing economy provides firms with access to credit at almost three times the rate of the average Caribbean country.[2]

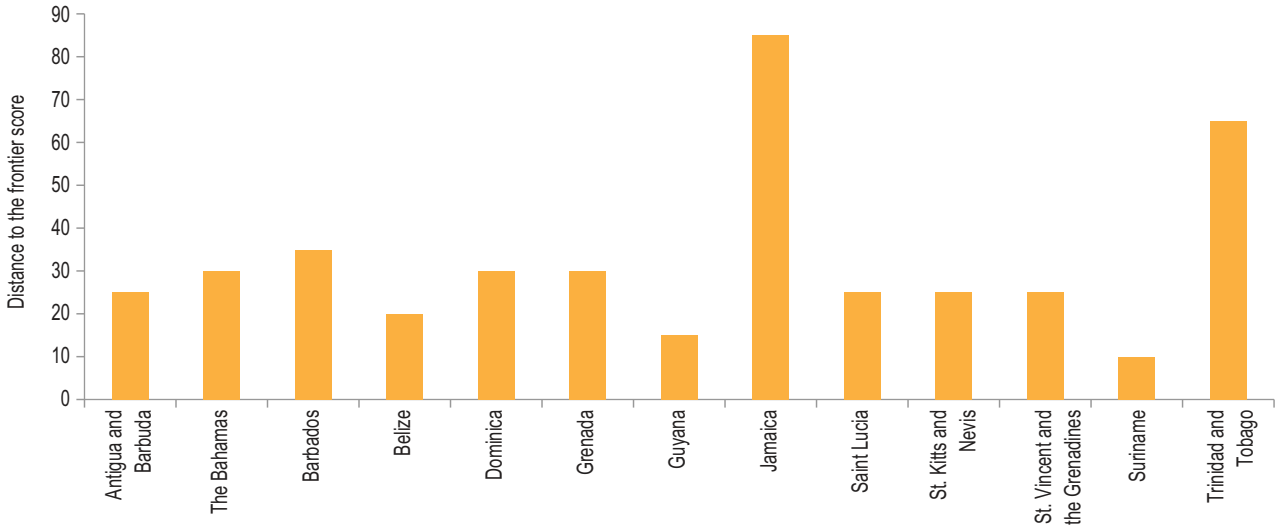
The background study for this chapter looked at whether restricted access to financing negatively affects innovation in the region. Specifically, it sheds light on this issue based on 13 developing countries in the Caribbean by assessing whether access to financing significantly affects firm-level decisions to innovate.[3] To answer this question, the study focused on innovation output (process and product innovation), which helped to identify whether credit constraints heterogeneously

[1] See Schumpeter (2013), Baumol (2002), and Aghion and Durlauf (2014), which illustrate the importance of innovation for growth and development.

[2] In World Bank (2016), the getting credit index measures the strength of credit reporting systems, as well as the effectiveness of collateral and bankruptcy laws in facilitating lending.

[3] Here reference to the Caribbean is characteristic of countries that are members of the Caribbean community in general and, specifically for this study, Antigua and Barbuda, the Bahamas, Barbados, Belize, Dominica, Guyana, Grenada, Jamaica, Saint Lucia, St. Kitts and Nevis, St. Vincent and the Grenadines, Suriname, and Trinidad and Tobago.

FIGURE 3.1. Distance to the Frontier Score for Getting Credit in Caribbean Economies



Source: World Bank (2016).

affected the decision to implement a particular type of innovation.[4] Further, this separation of innovation into different components made it possible to make specific comments on the type of innovation being pursued. Also, by deductive reasoning, it was possible to make some inferences about the relative cost of the types of innovation being pursued in the Caribbean given that there was no data to quantify this.

There are many studies on topics related to innovation and access to financing in the developed world. Most of these studies reported that constrained access to financing and innovation are negatively related. For example, Mohnen et al. (2008) pointed out that financial constraints negatively affected research and development (R&D) and were a major problem for firms wanting to pursue R&D.

Recent studies using the third Community Innovation Survey for the United Kingdom and Europe have shown that financial constraints are the second greatest constraint to innovating. These studies also highlighted that credit constraints are a key deterrent to firms deciding to innovate and the intensity of innovation (Savignac, 2008). Furthermore, financial constraints have been shown to be highly complementary to other impediments to innovation, such as perceived risk, innovation costs, limited skill in the workforce, limited collaboration within firms, and general obstacles in the business environment (Mohnen and Röller, 2005).

Based on this line of research, the policy prescription is that the modularity in which the obstacle is redressed is important since, if two obstacles complement each other, removal of one may attenuate the other. As such, there might be less reason to remove both at the same time. To be precise, Mohnen and Röller (2005) suggested that, when it comes to turning non-innovators into innovators, it is important to remove obstacles at the same time, such as easing access to financing and supporting an innovation ecosystem, or increasing the skilled labor force and reducing the regulatory burden. On the contrary, when it comes to increasing the amount of innovation, one policy at a time is sufficient.

With regard to developing countries, existing evidence is sparse, and includes only three

[4] Product and process innovations certainly do not cover the universe of innovation output, but available data were restricted.

published studies that have examined the relationship between innovation and access to financing in developing countries. Specifically, Ayyagari, Demirgüç-Kunt, and Maksimovic (2012) investigated the role of financing in undertaking innovation among 19,000 firms across 47 developing economies. They found that access to external financing was associated with greater firm innovation and that having highly educated managers; ownership by families, individuals, or managers; and exposure to foreign competition were associated with greater firm innovation. A noticeable shortcoming of this study was that, due to data limitations, techniques and approaches to managing endogeneity were limited.

Similarly, Gorodnichenko and Schnitzer (2013) used a broad array of sectors and countries in Eastern Europe and the Commonwealth of Independent States and found that financial constraints reduced the ability of domestically owned firms to innovate and export, hence retarding their ability to catch up technologically. In addition, they found that innovative firms were more likely to be affected by financial constraints and used instrumental variable techniques to identify the impacts of such constraints.

With regards to Latin America, Alvarez and Crespi (2015), using data on 10,000 Chilean firms in 2007, found that being credit constrained significantly and negatively affected innovation activity. Subsequent to dealing with several econometric problems associated with the endogeneity of the credit constraint indicator and the binary nature of the innovation variable, they also found that financial constraints were particularly severe for small firms and firms operating in the services sector, and were more restrictive when a firm was attempting to accumulate intangible assets.

Within this context, the study described in this chapter makes some important improvements in the analysis as it relates to developing countries. Specifically, it is the first study to focus on Small Island Developing States, which are known to have relatively inefficient input and output markets. So, it may be that results and relationships derived in the developed world do not hold for these economies. These are important understandings that may help to improve economic governance in policy development.

Further, the data source and variables are most closely related to Ayyagari et al. (2012) but differ in that the study used a panel dataset that employ econometric techniques proven to reduce the influence of unobserved firm heterogeneity.

In summary, the results showed that financial constraints reduced the propensity of all innovation output in Caribbean firms. This negative relationship was robust to various measures of access to financing and econometric techniques. Moreover, endogeneity is a strong influencer of the relationship between innovation and access to financing, and so efforts to reduce its impact are critical when estimating this relationship.

Literature Review

The main finding in the existing literature is that innovation is a key investment for firms to make if they are to achieve higher productivity and ultimately long-term viability (Mulkay, Hall, and Mairesse, 2001). Studies exploring this relationship have suggested that deliberate R&D leads to the discovery of new products and processes that ultimately shift the global technological frontier. Such studies present a clear link between innovation and national development. A third connecting dimension in this puzzle is the link between innovation and access to financing. Ayyagari et al. (2012) pointed out that the established connection between innovation and national development is borne out of its connection to the financial market. If innovation cannot be financed, then there is no developmental impact to be had from its fruition.

Within this context, Ruprah, Melgarejo, and Sierra (2014) suggested that restricted innovation might be to blame for the stagnating rates of growth in the Caribbean. Nevertheless, firms in the region, like the rest of the developing world, are far from the technology frontier and their innovative activities are not well understood (Ruprah et al., 2014).

As a means of identifying what is known about the relationship between innovation and access to financing, the study for this chapter explored the literature on the determinants of innovation and then reviewed existing knowledge about the relationship between innovation and access to financing.

Determinants of Innovation Output

Existing theoretical evidence shows that firms dedicate a differentiated proportion of resources to different types of innovation output (Cohen and Klepper, 1996). Nevertheless, empirical studies of innovation have been slow to differentiate between product and process innovations, focusing predominantly on product innovation (Hall, 2010). Notwithstanding, a few studies have attempted to distinguish between firm-level process and product innovation. For example, Cabagnols and Le Bas (2002) found that horizontal linkages were positively related to product innovation but not process innovation. One significant drawback to this analysis was that it investigated only innovating firms, without considering non-innovators.

On a broader level, studies that have tried to identify the determinants of firm-level innovation were more common in academic circles. Mostly, this topic has been looked at from an industrial organization or a business management perspective.

Industrial organization studies have hypothesized that the structural features of the industry in which a firm operates is the most useful explanatory variable for its level of innovation and possible persistence. Souitaris (2002) highlighted that analysis of these structural features requires researchers to analyze the effect of specific industry characteristics on a firm's innovation activities. Some of the most notable industry characteristics employed in the literature are market opportunities, technology opportunities, and appropriability conditions. A particular focus has been on the structure of the market from which firms derive their input and to which they sell their output as possible determinants of innovation. In fact, a great deal of attention has been placed on issues related to competition. For example, Aghion et al. (2005) found that competition and firm entry positively influenced innovation in industries that were close to the technology frontier. Nevertheless, there have been no conclusive results from these studies. Specifically, some studies have validated the classical Schumpeterian hypothesis, which suggests that firms in a monopolistic market structure and larger firms tend to have better innovative performance, while other studies contradict these positions (Schumpeter, 2013).

Business management studies have targeted identifying internal characteristics, structures, and strategies as determinants of firm-level innovation, known widely as the resource-based view. This line of research argues that the efficiency of a firm's operation is directly related to the unique blend of resources and capacities that it possesses (Dierickx and Cool, 1989). Researchers have evaluated a wide array of variables, with the most influential being found to be physical and human capital, size, corporate ownership, and financial resources (Andersson and Loöf, 2009). Recent resource-based research has focused on the experience of top managers. Some studies have found that, when a firm operates in a weak institutional environment, the knowledge about institutions acquired by their upper level management reduces the riskiness of business decisions.

Innovation and Access to Financing

One very popular driver found in the developed world literature is accessible capital. Specifically, firms either finance innovation from internal or external sources. External sources predominantly refer to bank loans or external equity, although some evidence suggests that government grants play a minor, though not insignificant, role (Czarnitzki, Hanel, and Rosa, 2011). Internal sources are mainly retained earnings. In their seminal paper, Modigliani and Miller (1958) pointed out that, in perfect markets, investment decisions are indifferent to capital structure. This suggests that, in perfect markets, the source of financing does not matter.

Nonetheless, since Arrow (1962) showed that the source of financing matters, several studies

have illustrated that this is even more true for investments in innovation. In particular, research has highlighted that information asymmetries arise as a result of the specificities involved with each innovation project and thus lenders demand a premium rate of return. It is these information asymmetries, and more broadly the intangible and uncertain nature of most types of innovation, that have driven the idea that financial constraints inhibit innovation. While internal sources of financing have been found to be the first choice to invest in innovation, these resources are not inexhaustible. As such, there is certainly a threshold above which external sources of financing must be called upon (Anton and Yao, 2002).

Historically, the relationship between innovation and financial constraints has been evaluated by assessing the sensitivity of R&D investment to different measures of the financial sector. In this regard, Himmelberg and Petersen (1994) found that internal financing had a positive relationship with R&D in high tech industries in the United States. Similarly, Mohnen et al. (2008) showed that financial constraints negatively affected R&D and were a major problem for firms wanting to pursue R&D. Furthermore, financial constraints have been shown to be highly complementary with other impediments to innovation, such as perceived risk, innovation costs, limited skill in the workforce, limited collaboration within firms, and general obstacles in the business environment (Mohnen and Röller, 2005).

As an extension, some recent research has looked at the effect of relationship banking on innovation in Italian manufacturing firms. Specifically, Herrera and Minetti (2007) pointed out that the longer a firm maintained a customer relationship with a particular bank, the higher the probability of introducing innovation. They also highlighted that this was more acute for product innovation. Benfratello, Schiantarelli, and Sembenelli (2008) adopted a similar strategy and also found contradictory evidence for Italian firms. In particular, they found that banking development affected the probability of process innovation, particularly for small firms, but found no robust evidence that it affected product innovation.

There are two major differences and controversies related to the existing literature on the relationship between innovating and financing. The first such controversy relates to the proxy used for access to financing. Some studies adopted a measure constructed from perception indexes. Almost all of these studies confirmed the negative relationship between innovation and access to financing. Some studies adopted a more quantitative measure of access to financing, using proxies such as debt ratios, gearing ratios, and other capital flow indicators. A few such studies found no significant relationship between financing and innovation.

The second controversy relates to the question of whether firms are capital constrained in general or specifically constrained for innovation projects. Although making this distinction is useful, the study did not consider it due to data limitations. Further, this was not a major concern given that most of the firms in the sample were small and medium sized. As such, being financially constrained in general or for specific investment projects should not have affected management decisions. Essentially, the asumption was that small firms treat all investment decisions with equal weight or, at least, that innovation may be the last investment choice. So, if a firm is constrained from making other investment choices, it will also be constrained from investing in innovation.

Finally, Alvarez and Crespi (2015) pointed out that the next big difference in the existing literature arises due to the identification challenge caused by the fact that access to financing is an endogenous variable when related to innovation. This is made clear when considering that innovation and access to financing may be determined simultaneously. In particular, more innovative firms may be less credit constrained because of persistence in innovation and, similarly, less credit constrained firms may be more innovative because they can invest in innovation. Moreover, the identification challenge may arise because there are specific unobserved characteristics of a firm that

drive its relative innovativeness and are also correlated with its relationship to capital markets. In this regard, panel data allowed for the use of econometric techniques that take the time series characteristics of innovation into consideration. Unfortunately, this kind of data has only been used in a few studies in the developed world and not in developing countries.

Data and Methodology

Data

Two datasets were used for this analysis: the World Bank's 2010 Latin American and Caribbean Enterprise Survey (LACES) and Compete Caribbean's 2014 Productivity, Technology, and Innovation (PROTEqIN) survey. They were combined using unique firm identifiers common to both surveys. The resulting dataset was an unbalanced panel with 4,387 firm-level observations, of which 1,539 firms were sampled twice. With the exception of Jamaica (618 firms; 14 percent) and Trinidad and Tobago (710 firms; 16 percent), the surveyed firms were relatively evenly distributed across the countries, with about 6 percent of the firms in the sample in each country, as shown in Table 3.1.

The sample was comprised of more firms in the services sector than in the manufacturing sector. Specifically, there were 3,364 (77 percent) services firms and 1,023 (23 percent) manufacturing firms. There was a lot of variation in the legal classification of the firms in the sample: 40 (1 percent) publicly listed companies, 1,461 (33 percent) privately held limited liability companies, 1,668 (38 percent) sole proprietorships, 557 (13 percent) partnerships, and 642 (15 percent) limited partnerships.

In terms of size, as shown in Table 3.2, micro-sized companies (five or less employees) accounted for a small proportion of the surveyed firms (7 percent). At the other extreme, there were roughly twice this number of large firms (more than 100 employees). As such, the sample was predominantly small- and medium-sized firms (between 20 and 100 employees), at 79 percent of the usable sample. Ruprah et al. (2014) argued that small and medium firms are the engines of growth in the Caribbean

TABLE 3.1. Distribution of Firms by Country

	Firms				
	Total	2010	2014	Manufacturing	Services
Antigua and Barbuda	282	151	131	56	221
Bahamas, The	277	150	127	75	202
Barbados	272	150	122	106	166
Belize	273	150	123	107	165
Dominica	276	150	126	50	226
Grenada	282	153	129	45	237
Guyana	285	165	120	100	185
Jamaica	618	376	242	123	494
Saint Lucia	278	150	128	120	158
St. Kitts and Nevis	275	150	125	57	218
St. Vincent and the Grenadines	287	154	133	91	196
Suriname	272	152	120	109	163
Trinidad and Tobago	710	370	340	158	552
Total	**4,387**	**2,421**	**1,966**	**1,023**	**3,364**

Source: LACES and PROTEqIN data.

TABLE 3.2. Innovation Output by Selected Firm Characteristics

	Firms	Process	Product	A2F
Micro (5 or less employees)	296	28	50	185
Small (6–19 employees)	1,842	196	287	1,125
Medium (20–99 employees)	1,628	207	336	926
Large (more than 100 employees)	614	131	184	283
Subsidiary	681	141	178	329
Exporter	1,070	201	286	579
Publicly Listed	40	21	24	12
Limited liability company	1,461	222	338	800
Proprietorship	1,668	165	258	1,033
Partnership	557	69	114	322
Limited partnership	642	75	114	341
Other	19	10	9	11

Source: LACES and PROTEqIN data.

and thus that understanding their experience as it relates to innovation is key to policy development.

Variables

In the study, innovation was represented by two dichotomous variables illustrating product and process innovation. Product and process innovation were each given the value 1 if a firm's manager self-reported that the firm had undertaken a product or process innovation in the previous three fiscal years. Of the 2,767 observations on product innovation, 857 (31 percent) firms reported a product innovation. Similarly, of the 2,763 observations on process innovation, 562 (20 percent) firms reported a process innovation.

To illustrate the idea of constrained access to financing, six questions related to a firm's finances were available from the surveys. Answers to these questions were transformed into variables as described below:

- Binary variable A2F1 was constructed based on firms' rankings of access to financing as a constraint on their operations on a Likert scale ranging from 0 (no obstacle) to 4 (severe obstacle). Variable A2F1 took the value of 1 if a manager self-reported that access to financing was an obstacle, and 0 otherwise.
- Dummy variable A2F2 was constructed based on three questions:
  1. What proportion of fixed asset purchases were financed using the following financing options: bank loans, savings, retained earnings, among others?
  2. Did you apply for a loan in the past three fiscal years?
  3. If no to (2), why? Did not need one, the interest rates were too high, collateral requirements were too high, among others.

  Dummy variable A2F2 took the value 1 if the firm did not use any bank financing for its most recent fixed asset purchase, did not apply for a loan, and gave a reason other than that they did not need one, and 0 otherwise.
- Dummy variable A2F3 was constructed using three questions:
  1. What proportion of working capital was financed using the following financing options: bank loans, savings, retained earnings, among others?
  2. Did you apply for a loan in the past three fiscal years?

3. If no to (2), why? Did not need one, the interest rates were too high, collateral requirements were too high, among others.

   Dummy variable A2F3 took the value 1 if the firm did not use any bank financing for working capital, did not apply for a loan, and gave a reason other than that they did not need one, and 0 otherwise.

- Dummy variable A2F4 took the value 1 if the firm wanted a loan but did not apply for one, and 0 otherwise.
- Dummy variable A2F5 took the value 1 if the firm did not have a line of credit but would have liked one, and 0 otherwise.
- Dummy variable A2F6 took the value 1 if the firm did not have an overdraft facility but would have liked one, and 0 otherwise.

As a baseline strategy, the study developed a six-tier index (A2F) that increased in intensity the more categories (A2F1 to A2F6) under which a firm qualified as constrained. To be precise, the index took a value of 1 if the firm only qualified as credit constrained under A2F1, 2 if it qualified under both A2F1 and A2F2, and so on. The resulting variable had 1,889 (43 percent) of the firms in the sample categorized as unconstrained, thus 57 percent of the firms were constrained. This index inevitably had a lot of variation given the nature of the underlying variables.

A lot of attention has been placed on competition as an explanatory factor in innovation (see Aghion et al., 2005; Aghion and Durlauf, 2014; and Ayyagari et al., 2012). Although there is no conclusive evidence from this line of research, the study included measures of competition in its estimations, though more focus was placed on informal competition given the assumed large informal private sector in the Caribbean. Similarly, it included measures of human capital, size, export activity, business climate, and managerial experience as highlighted by Cohen and Klepper (1996).

Empirical Strategy and Endogeneity

Uncovering a robust association between credit constraints and innovation would be a valuable result, but even more desirable would be a causal link in this association. In this regard, endogeneity issues associated with firm heterogeneity must be addressed. As highlighted by Bernard and Jensen (1999), firms are heterogeneous in terms of managerial ability, management effort, entrepreneurial orientation, and in the degree to which new technology is adopted and innovation generated. These are definitely features of a firm that may affect both innovation activities and outcomes, generating endogeneity in cross-sectional estimations, even after the adoption of sector or even industry fixed effects.

The study attempted two alternative strategies. First, I took advantage of the panel data structure to control for firm heterogeneity bias using firm fixed effects.[5] Nevertheless, the estimation technique (essentially differencing the data) would not control time variant, unobserved firm heterogeneity. This is of particular concern given that the period of analysis spanned a rather prolonged recessionary period for the region (2008–2014) that was marked by high debt and a heterogeneous business environment across the surveyed countries. To try to minimize any such influence, the study employed time fixed effects in all of its estimations. Even after this, it was not certain whether the results were not biased by time variant unobserved factors. However, this estimation was considered to be a credible first step in deciphering the nature of the relationship between innovation and access to financing.

Hence, as a formal representation of the estimations, the study specified the model as follows:

$$S_{it} = A2F_{it}'\beta + Size_{it}'\varphi + Skill_{it}'\delta + Website_{it}'\phi + Experience_{it}'\Upsilon + Competition_{it}'\theta + Export_{it}'\gamma + Regulation_{it}'\psi + \alpha_i + \tau_i + \varepsilon_{it}$$

where i indexes firms such that $i = 1,\ldots,N$ and t indexes time (t = 2010,2014). In Equation 1, S_{it} is innovation

[5] The study also, in unreported results, used the random effects estimator and performed a Hausman test to see which estimator was best for completeness. In all relevant cases, the test confirmed that the fixed effects estimator was best.

outcome (process or product innovation) and *A2F* is access to financing as described earlier. The other variables included in the model were size, proportion of skilled workers in the workforce, ownership of a website, senior manager's years of managerial experience in the sector, extent of informal competition in markets, export intensity, and impact of government regulations that could potentially influence innovation outcome. Similarly, α_i is a firm fixed effect, τ_i is a time fixed effect, and ε_{it} is a resulting error term with the usual properties. The baseline model was estimated using a linear probability model to exploit firm fixed effects.[6]

A limitation of the above strategy is that, if there are variables not included in the model (unobservables) that vary over time and are correlated with A2F, the coefficient on A2F will be biased and inconsistent, since in such case:

$$E(\in_{it}|x, w) \neq 0$$

where, for simplicity, the study used x to represent all observed covariates in Equation 1 and w is an unobserved variable.

Further, if A2F was imprecisely measured or simultaneously determined with the decision to innovate, it was assumed to be endogenous and thus the estimates were biased. To assess the extent of this being an issue and to some extent address the problems caused by it, the study employed an instrumental variables technique.[7] This technique is based on the fact that most commercial bank loans in the Caribbean are backed by collateral of over 100 percent of the loan value. Further, Pagés (2010) pointed out that fixed assets (land, buildings, and equipment) dominate as the collateral of choice for bank loans. This is even more noticeable in the Caribbean, where on average collateral requirements exceed 180 percent (Ruprah et al., 2014). Within this context, the data sample made it possible to obtain an estimate of the approximate value of land owned by the firm, which was used as an instrument for access to financing. The rationale was that this asset should have a strong influence on innovation but only through its impact on the firm's ability to access capital, either internally or externally.

To be precise, the higher the value of land held by a firm, the less likely the firm would be constrained financially. As a further attempt to clean this variable, the study used the lagged value of land. Essentially, the assumption was that this instrument was not correlated with error process in a regression on innovation output but was negatively correlated with constrained access to financing. For this reason, the value of existing material was not included since process innovation is highly correlated with material acquisition (Alvarez and Crespi, 2015).[8] While it was possible to test the correlation between lagged land value and access to financing (its validity is discussed later in the chapter), it was not possible to test for the correlation with the error process.

To examine if the results were robust to biases, the study undertook an instrumental variables strategy according to the following reduced form regression:

$$A2F_i = \pi_0 + Land'_{it-1}\pi_1 + \nu_i$$

[6] The limitations of the linear probability model are that resulting predicted values may be outside the [0,1] interval and a violation of homoskedasticity. As noted by Wooldridge (2012), these limitations are overstated since using robust standard errors solves the heteroskedasticity problem, and the occurrence of the predicted values outside [0,1] intervals in simulations does not seem to pose a big problem. In this study, less than 3 percent of such occurrences were recorded.

[7] Wooldridge (2012) noted that, unlike the fixed effects estimator, instrumental variables methods do not rely on strict exogeneity of the inputs for consistent estimation. Further, Cameron and Trivedi (2010) pointed out that, to achieve consistency of the instrumental variables estimator, three requirements have to be met. First, instruments need to be correlated with the endogenous regressors (in this case access to financing). Second, the instruments should not form part of the model directly or, more precisely, should not be related to the dependent variable other than through its influence on the endogenous independent variable. Finally, the instruments cannot be correlated with the error term.

[8] A more appropriate instrument here would be the value of land not used in the production process; however, the dataset did not make it possible to make this distinction.

where $Land_{it-1}$ is the estimated value of land owned by the firm in the last period. The predicted values from this regression were then used as an instrument for A2F in Equation 1.

Results

The main results are presented in Tables 3.3 and 3.4. This is only the third study on this topic in developing countries. Despite advances, there remains a myriad of challenges with data collection and reporting in the developing world that must be overcome before endogeneity can be controlled sufficiently in firm-level studies. Specifically, the dataset contained a total of 4,387 observations, with many missing observations related to variables for access to financing. Also, there were many missing observations that did not allow for adequate data transformation, such as the gearing ratio and financial debt. In particular, information on sales, the monetary value of collateral, liabilities, costs, and profitability, among others, are very rarely reported, thus making it difficult to identify instruments for access to financing. As such, and being mindful of multi-collinearity issues, the relationship for product and process innovations were estimated independently. It is crucial to exercise caution with strict interpretation of magnitudes as we documented significant variability in the eight regressions related to each dependent variable.

Nevertheless, both Tables 3.3 and 3.4 present eight columns of numbers. Column 1 is the baseline model, which differs from the next six only in how the A2F variable was constructed. In this model, A2F is an index that increased in intensity depending on the number of ways that a firm was identified as credit constrained. The next six columns dissect the index into its individual components and re-estimate the model accordingly. All these models were estimated using a linear probability model corresponding to Equation 1. The final column (Column 8) was estimated after implementing the previously described instrumental variables approach. Table 3.5 shows that the correlation between the A2F measures and land value was relatively small, indicating a weak instrument problem, but this was the best attempt to find an available instrument from the existing dataset. A more precise instrument would be the value of collateral not used in the production process; however, such information was not available within the dataset. Further, given that the model was exactly identified (one instrument for one endogenous variable), it is not possible to confirm the validity of this instrument with formal tests. For these reasons, the study adopted this strategy as a comparative check.

Consistent with Alvarez and Crespi (2015), the study removed those firms in the dataset that did not report being credit constrained using any of the measures and at the same time did not innovate. The rationale for this strategy was that only those firms that try to innovate discover that they are constrained in obtaining innovation financing. There were just over 5 percent of firms that fit this description. As illustrated in the tables, there was strong evidence that innovation and access to financing were negatively related, which is consistent with earlier work (Hall, 2010; Savignac, 2008; Gorodnichenko and Schnitzer, 2013; Mohnen et al., 2008; Alvarez and Crespi, 2015). In particular, firms that were credit constrained were significantly less likely to innovate with magnitudes larger for process innovation than product innovation. A potential justification for this, as suggested by Alvarez and Crespi (2015), is that process innovation is strongly related to purchasing machines and equipment—fixed assets that can be repossessed by banks in the event of default on debt. An interesting observation is that the coefficient on the index for A2F (column 1) is a lower bound on the magnitudes reported and an upper bound on the instrument (column 8). This finding is not surprising from two perspectives.

First, the coefficient on A2F is consistent with that found in previous research, specifically Alvarez and Crespi (2015), as it relates to magnitudes. In their study, Alvarez and Crespi (2015) found magnitudes related to process and product innovation of 0.038 and 0.119, respectively. Second, as indicated earlier, the instrument may be weak, inducing an

TABLE 3.3. Estimation Results with Product Innovation as the Dependent Variable

	(1) product1	(2) product2	(3) product3	(4) product4	(5) product5	(6) product6	(7) product7	(8) product
A2F	–0.096**	–0.531***	–0.521***	–0.361***	–0.355***	–0.460***	–0.697***	–1.136***
	(0.043)	(0.059)	(0.107)	(0.079)	(0.055)	(0.065)	(0.098)	(0.299)
size	0.052	0.035	0.005	0.070	0.091**	0.069	0.067	0.006
	(0.045)	(0.048)	(0.032)	(0.060)	(0.043)	(0.045)	(0.046)	(0.016)
skill	0.449***	0.409***	–0.043	0.202	0.381***	0.377***	0.107	0.357***
	(0.131)	(0.143)	(0.101)	(0.142)	(0.130)	(0.136)	(0.102)	(0.122)
website	0.115*	0.194***	–0.001	0.099*	0.085	0.018	0.069	–0.032
	(0.066)	(0.066)	(0.049)	(0.055)	(0.068)	(0.063)	(0.048)	(0.034)
man_experience	0.002	0.000	0.002	–0.000	0.005	0.000	0.003	–0.000
	(0.003)	(0.004)	(0.002)	(0.003)	(0.003)	(0.003)	(0.002)	(0.001)
informal_competition	–0.110*	–0.027	–0.134**	–0.030	–0.073	–0.101	–0.071*	–0.015
	(0.063)	(0.058)	(0.063)	(0.067)	(0.067)	(0.089)	(0.042)	(0.030)
export_intensity	0.002	–0.000	0.001	0.002	0.002	0.000	–0.000	0.001
	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)
gov_reg	–0.009*	–0.010***	–0.000	–0.007	–0.010*	–0.004	0.007	0.002
	(0.005)	(0.004)	(0.006)	(0.007)	(0.005)	(0.007)	(0.005)	(0.002)
time	0.229***	0.185***	–0.013	0.101*	0.212***	0.171***	0.023	–0.097
	(0.038)	(0.042)	(0.037)	(0.055)	(0.041)	(0.054)	(0.036)	(0.084)
_cons	0.054	0.564***	1.013***	0.551***	0.189	0.502***	0.644***	0.743***
	(0.172)	(0.185)	(0.144)	(0.211)	(0.161)	(0.192)	(0.187)	(0.194)
N	2,463	1,925	890	1,129	2,179	1,700	1,015	2,464
R-squared	0.132	0.259	0.598	0.316	0.231	0.418	0.677	–1.292
F	6.065	16.396	5.240	4.590	12.590	15.846	14.744	7.829

Source: Author's calculations.
Notes: Standard errors in parentheses. *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

upward bias in the coefficient. Nevertheless, the focus on the direction of the relationship and, thus, the indication of a negative relationship is some justification for persistence with an instrumental variable strategy.

Among the other variables that exerted a significant effect on innovation in the study, there was some evidence that increasing the proportion of skilled workers increased the likelihood of both process and product innovation. The more severe the competition from informal firms, the less likely a firm would, on average, innovate. Further, firms that adopted basic information communication technologies, in this case having or using a website, were

TABLE 3.4. Estimation Results with Process Innovation as the Dependent Variable

	(1) process1	(2) process2	(3) process3	(4) process4	(5) process5	(6) process6	(7) process7	(8) process
A2F	–0.165***	–0.747***	–0.746***	–0.649***	–0.637***	–0.798***	–0.662***	–1.517***
	(0.044)	(0.053)	(0.101)	(0.091)	(0.062)	(0.062)	(0.118)	(0.341)
size	–0.041	–0.018	–0.002	–0.058	–0.027	–0.095*	–0.028	–0.027
	(0.038)	(0.044)	(0.055)	(0.088)	(0.037)	(0.050)	(0.040)	(0.018)
skill	0.394***	0.208	0.288*	0.433**	0.478***	0.156	0.207	0.513***
	(0.122)	(0.128)	(0.152)	(0.217)	(0.137)	(0.157)	(0.174)	(0.140)
website	0.192***	0.176**	–0.043	0.091	0.126*	0.079	0.000	–0.038
	(0.074)	(0.071)	(0.059)	(0.104)	(0.070)	(0.071)	(0.066)	(0.039)
man_experience	0.010***	0.009***	0.004	–0.001	0.013***	0.001	0.009***	–0.001
	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.002)
informal_competition	–0.197***	–0.075	–0.036	–0.039	–0.195***	–0.152**	0.132	–0.077**
	(0.063)	(0.068)	(0.089)	(0.110)	(0.067)	(0.061)	(0.123)	(0.035)
export_intensity	–0.000	–0.001	–0.004	0.002	0.000	0.001	–0.003	0.001
	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.001)
gov_reg	–0.003	–0.006	0.008	–0.003	–0.006	0.003	0.005	0.001
	(0.005)	(0.005)	(0.005)	(0.008)	(0.005)	(0.006)	(0.007)	(0.002)
time	0.084**	0.059*	0.024	0.080	0.087**	0.035	–0.037	–0.337***
	(0.034)	(0.033)	(0.032)	(0.070)	(0.039)	(0.045)	(0.051)	(0.096)
_cons	0.202	0.773***	0.882***	0.956***	0.619***	1.220***	0.732***	0.989***
	(0.141)	(0.149)	(0.211)	(0.327)	(0.150)	(0.193)	(0.171)	(0.221)
N	2,431	1,813	630	899	2,114	1,546	758	2,460
R-squared	0.153	0.418	0.730	0.427	0.314	0.600	0.635	–3.159
F	9.861	38.358	15.022	6.451	19.272	40.505	6.621	3.580

Source: Author's calculations.
Notes: Standard errors in parentheses. *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

more likely, on average, to innovate. Nevertheless, there was at least one noticeable difference in the drivers of process and product innovation based on the study's estimations. In particular, managerial experience had no effect on the likelihood that a firm introduced a new product or service but positively influenced the likelihood that it engaged in process innovation, albeit only marginally. A possible reason for this is that more experienced managers are less affected by asymmetric information problems and, since process innovation is so closely related to acquiring fixed assets, are more likely to invest in process innovation. On the contrary, firms that consider government regulations burdensome

TABLE 3.5. Correlation Matrix

	Process	Product	A2F	Size	Skill	Website	Managerial experience	Informal competition	Export intensity	Government regulations	Land
Process	1										
Product	0.3166	1									
A2F	–0.0802	–0.0566	1								
Size	0.0479	0.1082	–0.0907	1							
Skill	0.0615	0.0674	–0.0309	0.0743	1						
Website	0.0664	0.0446	–0.077	0.2426	–0.052	1					
Managerial experience	0.0613	0.0733	–0.0369	0.1118	0.047	0.1118	1				
Informal competition	–0.0531	–0.0136	0.0496	–0.0498	–0.044	–0.0516	0.0518	1			
Export intensity	0.0178	0.0378	–0.0232	0.1374	0.0293	0.119	0.0002	–0.1576	1		
Government regulations	0.0329	0.0491	0.0055	0.0731	0.0777	0.0693	0.0727	0.0617	0.0055	1	
Land	0.165	0.1631	–0.1135	0.1917	0.039	0.0453	0.0566	0.0433	–0.0651	0.0229	1

are less likely to undertake product innovation, but there is no such evidence for process innovation.

Policy Implications

The results suggest several policy implications to enhance innovation in the Caribbean region. Study results indicate that, overall, credit constraints retard innovation and thus policy efforts can be generalized. In this regard, policy options that increase private sector credit will likely have a spillover effect on innovation outcomes. Further, with regards to debt financing, since most loans in the region must be collateralized with fixed assets, policies that help to reduce the risk profile and allow the use of moveable assets should be enhanced. As an alternative or complimentary approach, greater effort is needed to introduce new ways of financing investments in general, and for innovation in particular. Investment options could include peer-to-peer lending and crowd-funding, while not compromising risk management.

Similarly, governments across the region, being mindful of the high levels of public debt, should explore public sector funding options for highly innovative projects that have higher levels of risk, as these projects are most likely to suffer from asymmetric information problems and may not be funded by the financial sector.

Further, while not a direct finding of this study, there needs to be greater emphasis on increasing equity-related capital as an alternative for financing innovation in the region. Some studies have identified that equity financing is much more concerned with the overall value of the business model, which reduces the focus on collateral, and cash flow related indicators when evaluating projects (Savignac, 2008). Governments have a key role to play in this regard by providing the regulatory environment and institutional infrastructure to enable and develop the equity market in the region.

As regards those factors that have an effect on the decision to innovate, the other significant variables in this study provide some interesting

insights into the heterogeneous effect of other market and firm-level characteristics on innovation. For instance, the higher the proportion of skilled workers in a firm, the more likely the firm undertook innovation. Thus, policies that stimulate job training and skills upgrading may be very beneficial to firms that are considering innovating.

Similarly, the higher the number of informal competitors, the less likely a firm innovated. This is probably a result of the high sunk costs of innovating. When firms accept the sunk costs, competitors can imitate the innovation at a significantly lower investment. In an environment where an informal firm operates at a lower cost margin than a formal firm to begin with, it is not difficult to understand why formal firms would not innovate. In this regard, governments should push policies that encourage firms to formalize and create an enabling environment for firms to grow.

The results point to some crucial areas for future research. First, given the significant policy implications of this issue, it is important to expand the dataset to examine the extent to which these results are robust. Such a data expansion should account for internal funds for investing on innovation, which would give greater insight about how firms are financing innovation in the region. Similarly, a differentiation of financial constraints for innovation as opposed to other investments would allow a more detailed analysis of the link between innovation and credit restrictions.

Second, future data collection may greatly benefit researchers and policymakers by introducing an element that would allow analysis to be consistent with the ideal experiment suggested by Hall (2010). In this modification, firms should be asked how they would spend additional funds amounting to 10 percent of the previous year's turnover. Responses to this type of question would allow researchers to categorically estimate various econometric models related to firm-level investment studies. As it relates to this study, these responses would have made it possible to better categorize credit constrained firms that want to innovate and, therefore, have made it possible to conduct a more rigorous examination of the relationship.

Third, it is also important to extend this analysis to other developing countries to understand the extent to which the results are generalizable.

Finally, from a policy development perspective, it is vital to understand the importance of these findings on firm performance (e.g., sales growth, productivity, employment growth, and survival).

Conclusions

The existing economic thought is almost unanimous in its acceptance that innovation is an essential driving force for firm-level productivity, competitiveness, and economic growth, and ultimately development. The source and availability of financing is important for innovation in so far as it affects the decision to undertake and sustainably pay for innovation activities. Albeit, financing constraints may not affect all firms in the same way and to the same extent since the decision to innovate may be made after knowledge about the source of financing is already determined. Further, existing empirical evidence shows that highly innovative firms tend to have higher levels of intangible assets that are not very attractive as collateral in traditional banking (Hall, 2010). Consequently, both policymakers and industry leaders need to know if and to what extent financing constraints reduce investments in innovation. This chapter has shed some light on this issue for firms operating in the Caribbean.

Using an unbalanced panel dataset with 4,387 firms, the results, after controlling for endogeneity, unambiguously confirm that financial constraints retard innovative propensity. The evidence compliments earlier findings and extends them in several dimensions. Moreover, endogeneity is a major influencer of this relationship. Specifically, the failure to address it adequately could lead to the counterintuitive argument that firms with restricted access to financing innovate more than other firms.

References

Aghion, P., N. Bloom, R. Blundell, R. Griffith, and P. Howitt. 2005. "Competition and Innovation: An Inverted U Relationship." *The Quarterly Journal of Economics* 120(2):701–28.

Aghion, P., and S. N. Durlauf (eds). 2014. *Handbook of Economic Growth, Volume 2*. Amsterdam: North-Holland Elsevier Publishers.

Alvarez, R., and G. A. Crespi. 2015. "Heterogeneous Effects of Financial Constraints on Innovation: Evidence from Chile." *Science and Public Policy* 45(2):1–14.

Andersson, M., and H. Loöf. 2009. "Learning-by-Exporting Revisited: The Role of Intensity and Persistence." *Scandinavian Journal of Economics* 111(4):893–916.

Anton, J. J., and D. A. Yao. 2002. The Sale of Ideas: Strategic Disclosure, Property Rights, and Contracting." *Review of Economic Studies* 69(3):513–31.

Arrow, K. 1962. "Economic Welfare and the Allocation of Resources for Invention." In National Bureau of Economic Research, *The Rate and Direction of Inventive Activity: Economic and Social Factors*, pp.609–26. Princeton, NJ: Princeton University Press.

Ayyagari, M., A. Demirgüç-Kunt, and V. Maksimovic. 2012. "Firm Innovation in Emerging Markets: The Role of Finance, Governance, and Competition." *Journal of Financial and Quantitative Analysis* 46(06):1545–80.

Baumol, W. J. 2002. *The Free-Market Innovation Machine: Analyzing the Growth Miracle of Capitalism*. Princeton, NJ: Princeton University Press.

Benfratello, L., F. Schiantarelli, and A. Sembenelli. 2008. "Banks and Innovation: Microeconometric Evidence on Italian Firms." *Journal of Financial Economics* 90(2):197–217.

Bernard, A. B., and J. B. Jensen. 1999. "Exceptional Exporter Performance: Cause, Effect, or Both?" *Journal of International Economics* 47(1):1–25.

Cabagnols, A., and C. Le Bas. 2002. "Differences in the Determinants of Product and Process Innovations: The French Case." In A. Kleinknect and P. Mohen (eds), *Innovation and Firm Performance,* pp.112–49. London: Palgrave.

Cameron, A. C., and P. K. Trivedi. 2010. *Microeconometrics using Stata*. College Station, TX: Stata Press.

Cohen, W. M., and S. Klepper. 1996. "Firm Size and the Nature of Innovation within Industries: The Case of Process and Product R&D." *Review of Economics & Statistics* 78(2):232–43.

Czarnitzki, D., P. Hanel, and J. M. Rosa. 2011. "Evaluating the Impact of R&D Tax Credits on Innovation: A Microeconometric Study on Canadian Firms." *Research Policy* 40(2):217–29.

Dierickx, I., and K. Cool. 1989. "Asset Stock Accumulation and Sustainability of Competitive Advantage." *Management Science* 35(12):1504–11.

Gorodnichenko, Y., and M. Schnitzer. 2013. "Financial Constraints and Innovation: Why Poor Countries Don't Catch Up." *Journal of the European Economic Association* 11(5):1115–52.

Hall, B. H. 2010. "The Financing of Innovative Firms." *Review of Economics and Institutions* 1(1).

Herrera, A. M., and R. Minetti. 2007. "Informed Finance and Technological Change: Evidence from Credit Relationships." *Journal of Financial Economics* 83(1):223–69.

Himmelberg, C. P., and B. C. Petersen. 1994. "R&D and Internal Finance: A Panel Study of Small Firms in High-Tech Industries." *The Review of Economics and Statistics* 76(1):38–51.

Modigliani, F., and M. H. Miller. 1958. "The Cost of Capital, Corporation Finance and the Theory of Investment." *The American Economic Review*, 48(3):261–97.

Mohnen, P., F. C. Palm, S. S. Van Der Loeff, and A. Tiwari. 2008. "Financial Constraints and Other Obstacles: Are They a Threat to Innovation Activity?" *De Economist* 156(2):201–14.

Mohnen, P., and L.-H. Röller. 2005. "Complementarities in Innovation Policy." *European Economic Review* 49(6):1431–50.

Mulkay, B., B. H. Hall, and J. Mairesse. 2001. "Firm Level Investment and R&D in France and the

United States: A Comparison." In Deutsche Bundesbank (ed.), *Investing Today for the World of Tomorrow*. Berlin Heidelberg: Springer.

O'Sullivan, M. 2006. "Finance and Innovation." In J. Fagerberg et al. (eds), *The Oxford Handbook of Innovation*, pp. 240–65. Oxford: Oxford University Press.

Pagés, C. 2010. *The Age of Productivity: Transforming Economies from the Bottom Up*. Washington, DC and London: Inter-American Development Bank and Palgrave Macmillan.

Ruprah, I. J., K. A. Melgarejo, and R. Sierra. 2014. *Is There a Caribbean Sclerosis? Stagnating Economic Growth in the Caribbean.* Washington, DC: Inter-American Development Bank.

Savignac, F. 2008. "Impact of Financial Constraints on Innovation: What Can Be Learned from a Direct Measure?" *Economics of Innovation and New Technology*, 17(6):553–69.

Schumpeter, J. A. 2013. *Capitalism, Socialism and Democracy*. London: Routledge.

Souitaris, V. 2002. "Firm-Specific Competencies Determining Technological Innovation: A Survey in Greece." *R&D Management* 32(1):61–77.

Wooldridge, J. 2012. Introductory Econometrics: A Modern Approach. Boston, MA: Cengage Learning.

World Bank. 2016. *Doing Business 2016: Measuring Regulatory Quality and Efficiency*. Washington, DC: The World Bank.

4

Competition and Innovation in the Caribbean

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Productivity growth is essential for sustained economic development. While in the short run it may be possible to achieve economic growth by incorporating previously underemployed factors of production, it is necessary to increase output per unit of input over the long or even middle horizons. Krugman (1994:13) stated that: "Productivity isn't everything, but in the long run it is almost everything. A country's ability to improve its standard of living over time depends almost entirely on its ability to raise its output per worker."

In this way, a whole literature has developed to search for the main determinants of productivity. One factor that has received much attention is innovation. Overall, empirical literature shows that innovation leads to higher productivity, especially product innovation, as evidenced in the empirical surveys of Hall (2011) and Hall and Mohnen (2013). Although innovation is crucial for productivity growth, the main channels for innovation improvements are still not fully evidenced in the literature. A relatively recent and promising avenue of research focuses on the effects of competition.

For a long time, economists believed in a negative relationship between productivity and competition based on the Schumpeterian effect, where competition dissipates ex post economic rents, thus discouraging innovative efforts. This theoretical result has, nonetheless, been at odds with many empirical studies, such as Blundell, Griffith, and van Reenen (1999), who focused on manufacturing firms in England; Schmitz (2005), who analyzed the US and Canadian Iron Ore Industries; and Foster, Haltiwanger, and Krizan (2006), who studied the United States retail trade sector. Building on the insights of these previous results, Aghion et al. (2005) constructed a model with a positive "escape competition" effect besides the negative Schumpeterian effect, where firms in neck-and-neck industries try to innovate to differentiate themselves from their rivals and to increase their margins, profits, and market share. The net impact of competition on the rate of innovation depends on the interaction of these two effects, which arguably depends endogenously on the initial degree of competition in the industry: more competition fosters innovation when the initial level of competition is low, but the opposite occurs when the initial level of competition is high. Thus Aghion et al. (2005) derived an important theoretical result, which is tested empirically: competition and innovation relate in the form of an inverted-U.

Following Aghion et al. (2005), many papers have tested whether this inverted-U relationship could be corroborated (see *Literature Review*). But most of these studies are based on firm-level data from developed countries, and finding channels to improve productivity are most valuable to developing countries.[1]

This chapter attempts to address these questions using firm-level data from the Caribbean. Innovation in the developing world is scant and in small countries, like the Caribe, is even more rare. Thus, investigating how competition might impact innovation in this region could provide evidence of the effects of competition on innovation in other small developing countries. Moreover, there are at least two different types of competition in the developing world: formal and informal. Thus, we investigate how these two forms of competition are related to innovation.

The results back up the literature by showing an inverted-U shape relationship, especially when looking at informal competition. These results have important implications for public policy. For instance, knowing which sectors are in the ascending part of the U and which are in the descending part could play a crucial role in designing appropriate regulations and policies to support competition.

Literature Review

Competition has long been identified as an important mechanism for productivity. Ahn (2002) showed that its effects are mainly felt in three ways: static incentives, selection, and innovation. Static incentives occur when rents in a monopolistic firm are partially captured by managers and/or workers and thus competition can discipline these agents and improve efficiency. For instance, competition may improve the chances of bankruptcy and so induce greater effort. The selection channel involves better allocation of resources. When competition increases, technologically advantaged or better managed firms displace firms with inferior technology or substandard management.

The third component, innovation, is particularly important for productivity growth but is one where the impact of competition seems unclear. In fact, many theories have predicted a negative effect of competition on innovation, the rationale being ex post, where some degree of expected market power is necessary to provide incentives for innovators (the Schumpeterian effect), or ex ante, where rents obtained in concentrated markets are useful to finance innovations in a world of incomplete capital markets. But the empirical literature had been at odds with this result, identifying positive effects of competition as in Nickell (1996) or non-linear relations like Scherer (1967).

A hypothesis that has received much empirical support recently is the inverted-U shaped relationship between competition and innovation. A rationalization for this relationship was provided by Aghion et al. (2005).[2] In their model, industries can be *levelled*, with a low technological spread, or *unlevelled*, with a high technological spread. A levelled industry may become unlevelled if one of the neck-and-neck firms innovates. The reverse could occur if a laggard firm innovates, assuming there is a technological distance of at most one degree between firms, so leaders have no incentive to innovate. Thus, competition induces innovation in levelled industries, where each

[1] One example of a study of a developing country is Aghion, Braun, and Fedderke (2008), who investigated South Africa.

[2] There are other models that can explain the inverted-U relationship between competition and innovation. For instance, in Rauch (2008), the rationale for the decreasing part of the inverted-U is the same Schumpeterian effect as Aghion et al. (2005), but the increasing part is explained by a business stealing argument. If competition means more substitutability in a differentiated market, the more substitutability there is, the more the incentive to reduce price—reducing costs of producing by process innovation—and increase market share. Another example is Vives (2008), where the increase in the number of competitors in an industry lowers the residual demand for each firm (inhibiting innovation) but increases the elasticity of the residual demand (stimulating innovation). Most oligopolistic models show that the first effect tends to predominate, but the second one gains importance when non-innovating firms go bankrupt and there are termination costs. In this way, the elasticity effect may initially be predominant and become dominated only when the number of firms grows very large, generating the inverted-U relationship.

firm has the incentive to differentiate itself, but inhibits innovation in unlevelled industries, where competition reduces rents for laggard innovative firms (the traditional Schumpeterian effect).

But with a low initial degree of competition, industries should be levelled, since there are rents to stimulate innovation by laggards and not much pressure for competitive firms to differentiate from each other. So an increase in competition should induce more innovation in the aggregate. By a similar rationale, when competition is originally high, industries should be unlevelled—low rents would stimulate innovation by laggards and put pressure on competitive firms to differentiate themselves from the competition. So, in the aggregate, an increase in competition would induce less innovation. In this way, the model generates an inverted-U relationship between competition and innovation by a composition effect between levelled and unlevelled industries.

A first-order difficulty in testing this conjecture is how to properly measure competition and innovation. For innovation, there are problems with output measures. For example, with regards to patents, it is usually difficult to assess the economic importance of each one, and many innovations are non-patented. There are also challenges with measuring input measures. For instance, measures of research and development (R&D) may be distorted given tax incentives and the flexibility available in classifying many expenditures as R&D costs. Although both measures can be challenging, input measures seem more appropriate since competition primarily affects the incentive to innovate, not the degree of success.

The main problem, however, seems to be finding a good proxy for competition, as shown by Ahn (2002); Boone, van Ours, and van der Wiel (2007); and Holmes and Schmitz (2010). The measures typically used are market concentration measures, such as the Herfindahl Index, price cost margins (PCMs), and import penetration. But each of these has serious disadvantages. Concentration and import penetration measures may be misleading in the presence of potential entrants. For instance, a highly concentrated market may behave competitively if the exercise of market power stimulates entry. In the same way, a poorly concentrated market may not be competitive or sustained by dysfunctional market regulations. So, as competition increases, there may be an increase in concentration, as the strongest firms increase their market share. This is typically the case with the entrance of a large competitor, such as Wal-Mart, in a particular location where initially many small firms prevailed. As for PCMs, since costs may change for reasons other than competition, changes in this measure may not be indicative of competitive pressures. Even if these spurious changes in costs can be controlled for, other caveats remain. In a low competition environment, such as a monopoly, workers may benefit from higher rents, so when competition increases, profits might remain the same while the benefit to workers declines. There is also a problem of composition because when competition increases and strong firms (which should have higher PCMs) displace weak ones and so increase their weight in the industry, the industry-level PMC may rise accordingly. Besides, as marginal costs are generally unknown, PCMs are constructed as the ratio of sales minus costs over sales, and capital cost measures are usually hard to obtain. These shortcomings are just some examples of why these measures might not properly represent the degree of competition.

Bearing in mind these challenges, Boone et al. (2007) proposed a different measure of the degree of competition that overcomes most of these criticisms: profit elasticity (PE). Estimated at the sector level, PE is defined as the percentage decline in profits due to a percentage increase in costs. The idea is that, the more competition increases, the more a firm is punished for being inefficient. The main conclusion of Boone et al. (2007) was that, although PE is not a perfect measure of competition, in highly concentrated markets, where public policy is particularly welcomed, PE tends to point in the right direction, whereas PCMs can increase with more intense competition.

Despite these problems, a large empirical literature has developed to corroborate the inverted-U

relationship between competition and innovation. Although there have been some exceptions,[3] most of the literature supports the hypothesis. One of the first tests was the seminal paper by Aghion et al. (2005), who showed an inverted-U relationship between innovation (measured by patents weighted by citations) and competition (measured as 1–PCMs, with PCMs computed as operating profits minus financial costs over sales) at the industry level. Results remained when competition was instrumented to control for possible endogeneity problems.

Carlin, Schaffer, and Seabright (2004) focused on firms in transition economies to overcome the difficulty in ascertaining if variations in innovations were due to differences in the responsiveness to opportunities or differences in opportunities per se. Firms in these economies should simultaneously face opportunities and be under pressure to escape from inherited structures from a command economy. The main result showed an inverted-U relationship between firm growth and competition, measured as the number of competitors reported by the firm.

More recently, Tingvall and Karpaty (2011) tested the inverted-U hypothesis, focusing on Swedish firm-level data from the services sector. To measure competition, they used the Herfindahl Index and PE. Their results pointed to an inverted-U relationship between innovation (R&D) and competition, although there were some exceptions. The relationship was not valid for non-exporting firms and, when R&D was disaggregated, the relationship was valid for intramural R&D and training, but not for extramural (outsourced) R&D.

Drawing on firm- and industry-level data from the Netherlands, Polder, and Veldhuizen (2012) used investment in R&D over value added as their measure of innovation, and 1–PCM (at the micro and macro levels) and PE as proxies for competition. They found a consistent inverted-U relationship between innovation and competition, especially when using PE, the most indicative measure of competition. Two other results are worth mentioning. First, the majority of observations were concentrated in the ascending part of the inverted-U, indicating that, for most industries, competition is favorable to innovation. Second, Polder and Veldhuizen (2012) specifically tested, and found support for, the hypothesis that the marginal effect of competition changes from positive to negative as the technological spread in the industry increases. This corroborates the specific mechanism of the inverted-U relationship proposed by Aghion et al. (2005) (see footnote 2).

Hashmi (2013), using the same competition measure as Aghion et al. (2005), showed that the inverted-U relationship obtained for UK firms was not preserved when a much larger dataset of publicly listed United States manufacturing firms was considered. In that case, there was a negative effect of competition over innovation. Hashmi (2013) extended the Aghion et al. (2005) model, relaxing the assumption that the maximum technological gap between the leader and laggard in any industry could be only one step. He argued that both results can be explained in the modified model when the greater technology spread in the United States is considered. In that case, the relationship was negative, which is consistent with the Aghion et al. (2005) idea that competition discourages innovation in unlevelled industries.

Methodology

This study investigated how competition affects innovation using firm-level data. According to the literature, innovation can be classified as inputs and outputs. Expenditures on R&D or any aspect of a business that might lead to innovation, such as acquisition of machinery, are considered innovation inputs. As evidenced in Crespi and Zuñiga (2012), expenditures on innovation as a whole are much more relevant than just R&D in developing countries because firms in these countries tend to

[3] Using the same data as Aghion et al. (2005), Correa (2012) found a positive relationship between innovation and competition from 1973 to 1982 and no statistically significant innovation–competition relationship from 1983 to 1994. Correa (2012) argued that a structural break in the early 1980s was the reason for the inverted-U relationship found by Aghion et al. (2005).

adopt existing technologies rather than cutting-edge technologies. Innovation inputs may or may not lead to innovation outcomes, such as a new product or process. Innovation outcomes are represented by whether there is an innovative product and/or process and the percentage of new products in a firm's sales.

This chapter focuses on innovation input as measured by how much a firm spends on innovation, which consists of expenditures on R&D and on acquisition of machinery. Aghion et al. (2005) based their empirical investigation on the number of patents as a measure of innovation, but that measure has been criticized in the literature. Boldrin et al. (2011), for instance, argued that patents do not promote innovation, but rather retard it. Therefore, how much a firm spends on innovation might better represent innovation efforts.

As mentioned previously, empirical literature suggests that competition is positively correlated with innovation. Yet previous theoretical models and recent evidence have questioned whether innovation might be negatively related to innovation after a certain level of competition. This study followed the hypothesis that competition has an inverted-U relationship with innovation, as evidenced in the literature review. In summary, the basic econometric specification took the following form:

$$Y_{it} = a + b.X_{it} + c.X^2_{it} + d.Z_{it} + e_{it} \qquad (1)$$

where Y is innovation, X is competition, Z is a vector of controls, i is the firm, and t is time.

In this empirical model, the validation of the inverted-U relationship theory requires b > 0 and c < 0. Moreover, if results confirm this pattern, innovation begins to be negatively related to competition when competition reaches the value −b/2c. This may provide valuable information for public policy regarding regulating competition in the countries studied, which may constitute an important stimulus for innovation and productivity growth.

In the study's dataset, only a few firms invested in innovation, which led to a considerable number of zeros in the dependent variable. This limitation made it necessary to use techniques other than ordinary least squares (OLS). A Tobit model censored at zero was the alternative to deal with this shortcoming. The dataset also provided an advantage over other innovation datasets, such as the innovation module from the World Bank Enterprise Survey (WBES), because it is a longitudinal study instead of a cross-section. The longitudinal nature of the data made it possible to estimate using panel data methods, which might cancel out any unobservable time-invariant characteristics, such as managerial ability. In addition, it was possible to combine panel data techniques with the Tobit approach. In sum, the results are presented in increasing order of sophistication with each procedure, starting from the most naïve, OLS, then pure Tobit, followed by pure panel fixed effects, and finally, Tobit with random effects.[4]

To measure competition, we focused on two types: formal and informal. For the latter, firms were asked to rank informality as an obstacle to their business in five categories: no obstacle (0), minor obstacle (1), moderate obstacle (2), major obstacle (3), and very severe obstacle (4). The main advantage of this information is that it shows how much each firm sees informality as competition to its business. When a firm reports that informality is not an obstacle to its operations, it really means that informal firms are not competitors. If a firm states informality is a very severe obstacle, informal businesses are real competitors. Having a competition variable vary discretely from zero to four has been used in the literature, as in Carlin, Schaffer, and Seabright (2004) for a firm's freedom to raise prices.[5] Regarding formal competition, the analysis was focused on *price elasticity*

[4] An alternative would be to estimate Type II Tobit selection to control for censorship, but results have not converged because of the limited number of observations. To provide some evidence about the decision to innovate, we estimated a Probit using whether a firm invested in innovation or not as the dependent variable. Results are available in Table A4.1 in the Appendix.

[5] We also considered this measure averaged at the ISIC sector level to provide a more exogenous independent variable. Results using the most advanced method are available in Table A4.2 in the Appendix.

(PE) because it is the most robust measure of competition in the literature.[6]

PE is measured by estimating how much profit (in log) responds to changes in costs (also in log), as defined in the following equation:

$$ln(p_{it}) = a - b.ln(c_{it}) + e_{it} \quad (2)$$

where p_{it} is the profit of firm *i* and *cit* is the cost of firm *i*, both at time *t*, with *b* being the measure of PE. Ideally, PE is estimated at the sector level, such as the ISIC two-digit level, but the number of firms in each country did not made it possible to estimate it at this disaggregated sector level. Therefore, we calculated it for each country at the ISIC one-digit level, which provided two PEs for each country annually (one for manufacturing and the other for services). Since PE is estimated at the sector level, it is a more exogenous competition measure than others mentioned in the literature review.[7]

Data Description

This study used the firm-level data from two surveys recently done in the Caribbean: Latin American and Caribbean Economic Survey (LACES) and Productivity Technology and Innovation (PROTEqIN).

LACES was an enterprise survey implemented jointly by the Compete Caribbean Program and The World Bank. This survey interviewed top managers or business owners of a representative sample of private firms in the Caribbean in 2010. LACES followed the standardized methodology implemented by the WBES, with information on performance as well as a wide range of business environment topics. It also included a new module on innovation, with information on firms' abilities to create new products, incorporate new processes, and other related issues.

The PROTEqIN survey was completed in 2014. It aimed to provide further information about Caribbean firms interviewed with LACES, drawing more than 1,500 firms from that survey. The additional information from PROTEqIN included each firm's main characteristics, such as size by sales or by number of employees—factors related to innovation. Thus, PROTEqIN provided an extra year of information about Caribbean firms, which made it possible to construct a panel structure.

Although there are many similarities between the surveys, there are also differences. For example, LACES provides firm-level information for 14 countries, while PROTEqIN excluded the Dominican Republic. Table 4.1 shows the number of firms interviewed for both surveys in each country, as well as the total number of observations in both surveys. In total, there are more than 4,500 firm-level observations, with 1,890 firms being surveyed twice (corresponding to 78 percent of the firms surveyed in 13 countries selected from LACES and PROTEqIN).[8]

Descriptive Statistics

This study investigated how much a firm invested in innovation, either in R&D or in acquiring machinery, splitting the sample into two categories: firms that spent funds on innovation (spent) and firms that did not (not spent).[9] Table 4.2 shows how these two groups were distributed among the surveyed countries, including splitting LACES into three subgroups: all firms in the survey, including those from the Dominican Republic, a group excluding firms from the Dominican Republic (no DR), and a group including only those firms surveyed twice (only panel firms).

As expected, only a tiny fraction of Caribbean firms spent resources on innovation, with more than 80 percent not investing, regardless of the

[6] Two other alternatives were also considered: Price Margin Cost and Mark Up. Results, which remained qualitatively similar, are available on request.

[7] As an alternative, we also estimated the most advanced method using PE estimated at ISIC sector classification but considering the Caribbean as a single country. Outcomes are presented in Table A4.3 in the Appendix.

[8] This creates an additional problem as the percentage of firms surveyed twice ranges from 42 percent in Guyana to more than 90 percent in Trinidad and Tobago. This shortcoming is discussed in *Results*.

[9] We refrained from using the term innovators and non-innovators as these generally refer to firms that have either innovated or not.

TABLE 4.1. Number of Firms in Each Survey and Total Number of Observations

Country	LACES	PROTEqIN	Number of observations
Antigua and Barbuda	151	131	282
Bahamas, The	150	127	277
Barbados	150	123	273
Belize	150	122	272
Dominica	150	126	276
Dominican Republic	360	—	360
Grenada	153	129	282
Guyana	165	70	235
Jamaica	376	242	618
Saint Lucia	150	128	278
St. Kitts and Nevis	150	125	275
St. Vincent and the Grenadines	154	133	287
Suriname	152	94	246
Trinidad and Tobago	370	340	710
Total	2,781	1,890	4,671

Source: Authors' elaboration based on LACES and PROTEqIN.

subsample or survey. One particular issue that should be noted is that the restricted LACES samples (no DR and only panel firms, the middle columns) showed an even lower share of firms having invested in innovation. While nearly 18 percent of all LACES firms (all 14 countries) invested in innovation, only 13 percent of those in the restricted samples invested. This means that the subsample used for the panel had a lower percentage of firms investing in innovation than all firms in LACES. Percentages from all firms in LACES and in PROTEqIN were much more alike. We concluded that more firms invested in innovation over the three years between surveys. Although this seems interesting, it is important to emphasize that we do not know what happened to the firms that did not complete the PROTEqIN survey. It may be that those not surveyed twice went bankrupt, creating a selection bias. Considering LACES surveyed a representative sample of firms in these countries but PROTEqIN might not have, we believed that it was important to explore all the LACES subsamples to evaluate whether they might have distorted the results.

Firms do not spend on innovation at the same magnitude because of their size or any other specific characteristic. Table 4.3 presents innovation expenditures to total sales and to the number of employees to compare the magnitude of spending across firms.[10]

The magnitude of spending based on sales shows that firms invested less in 2014 than in 2010. On average, they invested nearly 5 percent of sales on innovation based on the LACES survey, declining to less than 2 percent in the period used for the PROTEqIN survey. In other words, investment in innovation on average declined by more than half. However, the ratio of innovation expenditures

[10] Averages across firms were calculated by simple means in Tables 4.3 and 4.4 because sample weights were constructed at the country level.

TABLE 4.2. Number of Firms that Spent on Innovation in the Caribbean

Surveys	LACES				LACES		PROTEqIN	
	All firms		No DR		Only panel firms			
Subsamples	#	%	#	%	#	%	#	%
Not spent	2,285	82.20	2,093	86.50	1,640	86.80	1,560	82.50
Spent	496	17.80	328	13.50	250	13.20	330	17.50
Total	**2,781**	**100**	**2,421**	**100**	**1,890**	**100**	**1,890**	**100**

Source: Authors' elaboration based on LACES and PROTEqIN.

TABLE 4.3. Amount of Innovation Spending

Surveys	LACES	LACES	LACES	PROTEqIN
Subsamples	**All firms**	**No DR**	**Only panel firms**	
Innov expenditures/ sales (%)	4.9	4.3	4.8	1.9
Innov expenditures/ workers (US$)	337.71	490.12	566.85	496.55

Source: Authors' elaboration based on LACES and PROTEqIN.

to number of employees showed no specific result. On one hand, all firms interviewed for LACES invested less than US$400 per employee. On the other hand, the panel firms invested more than US$550 per employee in 2010, declining to less than US$500 per employee in 2014. We viewed these comparisons cautiously, as there may be a selection bias in the PROTEqIN data.

This study focused on the relationship between firms' investments in innovation and competition, thus we compared how the degree of competition differed between firms investing and not investing, as shown in Table 4.4.

Overall, the degree of formal competition, measured by PE, decreased over time, while informal competition increased. The values in LACES were higher in PE and lower in informality compared to the respective figures in PROTEqIN.[11] Of note, the differences between those investing and not investing vanished over time, since figures in PROTEqIN were practically equivalents. Two different patterns can be seen for LACES. On one hand, those investing in innovation appear to have faced lower competition from the formal sector. On the other hand, informality appears to have been a greater obstacle for those investing compared to those not investing. This initial analysis suggests that competition had a greater impact on innovation in 2010 than it had four years later. Additionally, formal competition appears to have been negatively related to firms' decisions to invest in innovation, while informal competition was positively related. However, these insights needed to be corroborated under scrutiny of the econometric investigation.

TABLE 4.4. Degree of Competition

Surveys	LACES	LACES	LACES	PROTEqIN
Subsamples	**All firms**	**No DR**	**Only panel firms**	
PE				
Not spent	1.051	1.062	1.060	1.028
Spent	0.984	1.016	0.994	1.028
Total	**1.039**	**1.056**	**1.051**	**1.028**
Informality				
Not spent	1.384	1.34	1.299	1.602
Spent	1.679	1.537	1.48	1.6
Total	**1.437**	**1.366**	**1.323**	**1.602**

Source: Authors' elaboration based on LACES and PROTEqIN.

Results

We used an econometric approach to further investigate the link between innovation and the degree of competition firms face. We estimated the econometric specification described in equation 1 from the most naïve method (OLS) to the most sophisticated (panel effects jointly with Tobit).

In this section, we present results using innovation expenditures divided by total sales as the dependent variable.[12] For measures of competition, we used PE and perceived competition from the informal sector.

Table 4.5 shows the outcomes estimating equation 1 by OLS. Column 1 presents both surveys, while columns 2 to 4 only LACES and column 5 only PROTEqIN. Columns 2 to 4 differ in terms of the subsamples mentioned previously. As explained

[11] Most of the averages are statistically different across those spending or not on innovation.

[12] Outcomes using innovation expenditures over number of employees provide similar results and are available upon request. Moreover, results using other measures of competition, such as PCM and Mark Up, are also available upon request.

TABLE 4.5. Estimating Equation 1 by OLS using PE and Informality
(dependent variable: innovation expenditures/total sales)

Variables	(1) All firms and surveys	(2) LACES All firms	(3) LACES No DR	(4) LACES Panel firms	(5) PROTEqIN All firms
PE	0.0214 (0.051)	0.1106* (0.065)	0.1272** (0.063)	0.1720** (0.078)	0.0717 (0.087)
PE squared	−0.0084 (0.022)	−0.0450 (0.031)	−0.0556* (0.029)	−0.0736** (0.036)	−0.0203 (0.039)
Informality	0.0033*** (0.001)	0.0046*** (0.002)	0.0028* (0.001)	0.0030* (0.002)	0.0024 (0.002)
Informality squared	−0.0009*** (0.000)	−0.0012*** (0.000)	−0.0007** (0.000)	−0.0008* (0.000)	−0.0005 (0.000)
Log(size)	0.0006 (0.001)	−0.0001 (0.001)	−0.0007 (0.001)	−0.0006 (0.001)	0.0017* (0.001)
Log(age)	−0.0006 (0.001)	−0.0014 (0.001)	−0.0003 (0.001)	−0.0004 (0.001)	0.0014* (0.001)
Export	0.0039** (0.002)	0.0037* (0.002)	0.0025* (0.001)	0.0030* (0.002)	0.0042** (0.002)
Foreign	−0.0014 (0.002)	−0.0037** (0.002)	−0.0008 (0.001)	−0.0004 (0.002)	0.0008 (0.004)
Internal funds	0.0077*** (0.001)	0.0117*** (0.002)	0.0090*** (0.002)	0.0098*** (0.002)	−0.0007 (0.002)
Constant	−0.0141 (0.028)	−0.0614* (0.035)	−0.0676** (0.034)	−0.0929** (0.043)	−0.0594 (0.048)
Country dummy	Yes	Yes	Yes	Yes	Yes
Sector dummy	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	No	No	No	No
Observations	4,480	2,640	2,307	1,804	1,840
R-squared	0.0968	0.1319	0.1553	0.1568	0.1515

Source: Authors.
Notes: Robust standard errors in parentheses. * Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

previously, the restricted sample from LACES might have introduced some bias that should be considered in the estimation approach.

Looking at the controls, most show the expected sign, yet consistent differences emerge between the two datasets. Surprisingly, size is positively related to innovation expenditures only based on PROTEqIN data. One possible explanation is that the size effects are being captured by other covariates correlated to size in the LACES data—for instance exports. Export status and use of internal funds are positively related to innovation in all subsamples of LACES, while foreign status is negatively correlated only when using all firms. Looking at the estimation using both surveys, export status and internal funds

remain positive, yet the effect of size encountered in PROTEqIN vanishes.

Outcomes related to the degree of competition provide interesting insights. First, informal competition seems to be more correlated to innovation expenditures than formal competition, since informal is positive when both surveys are considered, while formal is not. This suggests that formal competition was relevant for innovation expenditures, but its effect declined over time. Second, although the degree of competition is positively related to innovation expenditures, its effects decline as competition rises, since the values squared are negative. Moreover, informal competition achieves its maximum value a little before being considered a moderate obstacle, yet it only reduces competition when a firm considers it a very severe obstacle.[13]

As the dependent variable was inflated with zeros, we needed to use Tobit to eliminate the bias. Table 4.6 shows the outcomes using the same structure as in Table 4.5. The first difference occurs in the controls, which become much more relevant in explaining innovation expenditures than estimates by OLS. For instance, firm size is now positively related to the dependent variable in both surveys, either isolated or jointly (column 1). This result confirmed the initial interpretation in the descriptive statistics, thus differences in innovation according to firm size (measured by the number of employees) remained even after controlling for total sales. Age also became significant to explain innovation expenditures when using LACES, yet its signal was negative, which means that younger firms were more inclined to spend financial resources on innovation than older firms. Export status and use of internal funds to invest remained qualitatively the same.

As for the degree of competition faced by firms, results remained qualitatively similar to previous results, yet values changed. Looking at the figures using both surveys (column 1), informal competition remains positive at a declining rate, while formal competition remains irrelevant. Considering each survey, formal competition shows a positive relation to innovation at a declining rate for LACES, regardless of the subsample, while outcomes with informal competition has a declining rate only when considering all firms. In PROTEqIN, the relationship between formal competition and innovation is encountered, although when combining it with LACES, it vanishes. This is a surprising result since formal competition seems to matter for both surveys individually, but not jointly. Evaluating when informal competition achieves its maximum, we observe that the value rises to 2.14 using values from column 1. The implication of this new value is that all levels of informal competition are positively related to innovation expenditures even in extreme cases (very severe).[14] This suggests that competition increases innovation expenditures over sales even when competition achieves its maximum value. As for formal competition, the hump was estimated to be around 1.2, considering significant parameters.

Although results in Table 4.6 (Tobit) are more accurate than Table 4.5 (OLS), they might still be biased since there are unobservable firm characteristics, such as management, that may be correlated to the independent variables. Therefore, Table 4.7 presents the results of estimating equation 1 using a panel structure. The first column of results shows estimations using the balanced panel by considering fixed effects.[15] Tobit with random effects estimations are presented in the last two columns of this table with unbalanced and balanced panels.

[13] The maximum value was obtained by –b/2c, which is −0.0033 / (−0.0009 × 2) or 1.8 when using both surveys.

[14] While we found negative values using the estimated parameters shown in Table 4.5 for firms reporting informality as a very severe obstacle (4), using the Tobit model, we encountered a positive value, more precisely 0.0167 × 4 − 0.0039 × 16, which is 0.0044.

[15] To provide further results, we also estimated using PE in a more disaggregated sector classification considering the Caribbean as a whole country. In total, we had 15 sectors for each year. Additionally, we estimated using ISIC sector average in informality to have more exogenous explanatory variable. However, results are similar to those obtained in Table 4.7 and are available upon request.

TABLE 4.6. Estimating Equation 1 by Tobit using PE and Informality
(dependent variable: innovation expenditures/total sales)

Variables	(1) All firms and surveys	(2) LACES All firms	(3) LACES No DR	(4) LACES Panel firms	(5) PROTEqIN All firms
PE	−0.1462 (0.253)	1.8476*** (0.453)	1.6693*** (0.415)	2.6287*** (0.553)	1.1573* (0.604)
PE squared	0.0850 (0.116)	−0.7681*** (0.202)	−0.6608*** (0.185)	−1.0600*** (0.242)	−0.4643* (0.273)
Informality	0.0167*** (0.006)	0.0249*** (0.008)	0.0182** (0.008)	0.0198* (0.011)	0.0011 (0.008)
Informality squared	−0.0039*** (0.001)	−0.0055*** (0.002)	−0.0034 (0.002)	−0.0038 (0.003)	−0.0001 (0.002)
Log(size)	0.0108*** (0.002)	0.0054* (0.003)	0.0043 (0.003)	0.0077* (0.004)	0.0177*** (0.003)
Log(age)	−0.0037 (0.004)	−0.0083* (0.005)	−0.0045 (0.005)	−0.0053 (0.006)	0.0055 (0.005)
Export	0.0285*** (0.006)	0.0323*** (0.008)	0.0295*** (0.009)	0.0326*** (0.011)	0.0238*** (0.007)
Foreign	−0.0018 (0.007)	−0.0190* (0.011)	−0.0032 (0.011)	0.0081 (0.014)	0.0045 (0.009)
Internal funds	0.0643*** (0.006)	0.1072*** (0.009)	0.0932*** (0.009)	0.0991*** (0.012)	0.0006 (0.008)
Constant	−0.1129 (0.136)	−1.2423*** (0.254)	−1.1443*** (0.234)	−1.6999*** (0.316)	−0.8255** (0.330)
Country dummy	Yes	Yes	Yes	Yes	Yes
Sector dummy	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	No	No	No	No
Observations	4,480	2,640	2,307	1,804	1,840

Source: Authors.
Notes: Standard errors in parentheses. * Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

Overall, controls show similar results from previous methods, the only difference being that foreign firms appear to be positively related to innovation. Looking at the values for competition, formal remains not significant in explaining innovation, while informal maintains its influence. Looking at these values, we infer the hump is 1.6 using fixed effects and roughly 2 using Tobit random effects. Although the values are different, firms that reported competition was very severe might invest less in innovation due to competition considering the hump estimated by FE (Table 4.8). As noted in this table, as informal competition increases, its effects on innovation expenditures over sales rises until reaching informality as a moderate obstacle. After that, the impact of informality declines yet is positive for major obstacle, eventually reaching negative values when very severe obstacle is using FE, yet not using Tobit RE.

TABLE 4.7. Estimating Equation 1 by FE and Tobit RE using PE and Informality

	(1)	(2)	(3)
Variables	**Balanced – FE**	**Unbalanced – Tobit RE**	**Balanced – Tobit RE**
PE	0.0091 (0.054)	−0.1712 (0.249)	−0.2206 (0.261)
PE squared	−0.0058 (0.025)	0.0963 (0.115)	0.1179 (0.121)
Informality	0.0042** (0.002)	0.0172*** (0.006)	0.0134** (0.006)
Informality squared	−0.0013*** (0.000)	−0.0041*** (0.001)	−0.0033** (0.002)
Log(size)	−0.0009 (0.002)	0.0106*** (0.002)	0.0124*** (0.003)
Log(age)	0.0035 (0.003)	−0.0038 (0.004)	−0.0011 (0.004)
Export	0.0163*** (0.006)	0.0285*** (0.006)	0.0273*** (0.006)
Foreign	0.0317*** (0.008)	−0.0015 (0.007)	0.0112 (0.008)
Internal funds	0.0027 (0.002)	0.0635*** (0.006)	0.0474*** (0.007)
Constant	−0.0333 (0.030)	−0.0985 (0.134)	−0.0618 (0.140)
Country dummy	No	Yes	Yes
Sector dummy	Yes	Yes	Yes
Year dummy	No	Yes	Yes
Observations	3,644	4,480	3,644
R-squared	0.0871		
Number of UNIQUEID_LACES	1,851	2,687	1,851

Source: Authors.
Notes: Standard errors in parentheses. * Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

Conclusions

This chapter evaluates how competition affects innovation expenditures in the Caribbean. Since this is a developing region, we argued that competition could come from the formal and the informal markets. Looking at both types of competition, we found that when competition rose, innovation expenditures increased, especially when competition came from the informal market. Nevertheless, its power to affect innovation expenditures declined after a certain threshold, which corroborates the idea of an inverted-U relationship between competition and innovation. Firms facing more than a moderate level of informal competition continued to be affected positively, but

TABLE 4.8. Informal Competition Effects on Innovation Expenditures

Informality values	Balanced – FE	Unbalanced – Tobit RE	Balanced – Tobit RE
0 – No Obstacle	0	0	0
1 – Minor	0.0029	0.0131	0.0101
2 – Moderate	0.0032	0.018	0.0136
3 – Major	0.0009	0.0147	0.0105
4 – Very Severe	−0.004	0.0032	0.0008

Source: Authors.

higher levels of competition reduced their efforts in innovation.

Based on these results, policymakers face a tradeoff. On one hand, innovation rates in the manufacturing sector are superior to those in the services sector. While manufacturing firms on average invested nearly US$600 per employee, or 1 percent of sales on innovation, firms in services spent less than half of that (US$298 per employee, or 0.4 percent of sales). Therefore, to increase innovation expenditures in their countries, policymakers would want to incentivize more innovation in the services sector. However, it is important to highlight that Criscuolo (2009) found that investment in innovation is generally higher in manufacturing than in services because the elasticity of innovation and productivity tends to be higher in manufacturing than in services.

On the other hand, firms in services face more competition than those in manufacturing, not only in the formal market but also in the informal market. Firms in the services sector are elastic in terms of formal competition (average PE of 1.07), while the manufacturing sector is inelastic (average PE of 0.97). Firms in services perceive the informal market as more of a threat, on average at 1.52, than those in manufacturing, at 1.48. Therefore, increasing competition in the manufacturing sector, where the degree of competition is perceived as lower, might have a higher impact than increasing it in the services sector.

Although attempting to discern which sector might lead to higher innovation expenditures in the Caribbean region due to increased competition is challenging, the results show that the level of competition is still below the maximum degree of competition estimated. In terms of competition in the formal sector, when we found some non-significant estimates for both PE and its square, the maximum level of competition is around 1.2, which means that there is still room for increases in innovation expenditures through increases in competition. In terms of informal competition, the estimates suggest the same. Most of the estimates suggest that the maximum level of informal competition is moderate (around 2). Caribbean firms face levels at around 1.5 on average, which indicates that combating informality might reduce innovation expenditures. Therefore, informality might still be important for competition and any policy to combat them might reduce innovation expenditures in the short run. However, it is important to emphasize that expansion of the formal sector in the long run could reduce informality, since informal firms are less productive, as pointed out by La Porta and Shleifer (2014). As a consequence, formal competition might become more influential in promoting more innovation in the long run. Thus, the aim is to create a business environment that promotes the expansion of the formal sector, which will eventually raise innovation rates due to increased competition in the most efficient and productive firms: formal.

References

Ahn, S. 2002. "Competition, Innovation, and Productivity Growth: A Review of Theory and Evidence." OECD Working Paper 317. Paris: Organisation for Economic Co-operation and Development.

Blundell, R., R. Griffith, and J. van Reenen. 1999. "Market Share, Market Value and Innovation in a Panel of British Manufacturing Firms." *Review of Economic Studies* 66:529–54.

Boldrin, M., J. Allamand, D. Levine, and C. Ornaghi. 2011. "Competition and Innovation." Cato Papers on Public Policy, Vol. 1. Washington, DC: Cato Institute.

Boone, J., J. van Ours, and H. van der Wiel. 2007. "How (Not) to Measure Competition." CPB Discussion Paper 37. The Hague: CPB Netherlands Bureau for Economic Policy Analysis.

Carlin, W., M. Schaffer, and P. Seabright. 2004. "A Minimum of Rivalry: Evidence from Transition Economies on the Importance of Competition for Innovation and Growth." *Contributions to Economic Analysis & Policy* 3(1): Article 17.

Correa, J. A. 2012. "Innovation and Competition: An Unstable Relationship." *Journal of Applied Econometrics* 27(1):160–6.

Crespi, G., and P. Zuñiga. 2012. "Innovation and Productivity: Evidence from Six Latin American Countries." *World Development* 40(2):273–90.

Criscuolo, C. 2009. "Innovation and Productivity: Estimating the Core Model across 18 Countries." In: *Innovation in Firms: A Microeconomic Perspective*, Chapter 3. Paris: OECD Publishing.

Foster, L., J. Haltiwanger, and C. Krizan. 2006. "Market Selection, Reallocation, and Restructuring in the U.S. Retail Trade Sector in the 1990s." *Review of Economics and Statistics* 88(4):748–58.

Hall, B. H. 2011. "Innovation and Productivity." *Nordic Economic Policy Review* 2:167–204.

Hall, B. H., and P. Mohnen. 2013. "Innovation and Productivity: An Update." *Eurasian Business Review 3*(1):47–65.

Hashmi, A. 2013. "Competition and Innovation: The Inverted-U Relationship Revisited." *The Review of Economics and Statistics* 95(5):1653–68.

Holmes, S., and J. Schmitz. 2010. "Competition and Productivity: A Review of Evidence." *Annual Review of Economics* 2:619–42.

Krugman, P. 1994. *The Age of Diminishing Expectations: US Economic Policy in the 1990s*. Cambridge: The MIT Press.

La Porta, R., and A. Shleifer. 2014. "Informality and Development." *The Journal of Economic Perspectives* 28(3):109–26.

Nickell, S. 1996. "Competition and Corporate Performance." *Journal of Political Economy* 104(4):724–46.

Polder, M., and E. Veldhuizen. 2012. "Innovation and Competition in the Netherlands: Testing the Inverted-U for Industries and Firms." *Journal of Industry, Competition and Trade* 12:67–91.

Rauch, F. 2008. "An Explanation for the Inverted-U Relationship between Competition and Innovation." Vienna Economic Papers 0813. Vienna, Austria: Department of Economics, University of Vienna.

Scherer, F. 1967. "Market Structure and the Employment of Scientists and Engineers." *American Economic Review* 57:524–31.

Schmitz, J. 2005. "What Determines Productivity? Lessons from the Dramatic Recovery of the U.S. and Canadian Iron Ore Industries Following their Early 1980s Crisis." *Journal of Political Economy* 113(3):582–625.

Tingvall, P., and P. Karpaty. 2011. "Service-Sector Competition, Innovation and R&D." *Economics of Innovation and the New Technology* 20(1):63–88.

Vives, X. 2008. "Innovation and Competitive Pressure." *The Journal of Industrial Economics* 56(3):419–69.

Appendix

TABLE A4.1. Estimating Decision to Spend on Innovation by Probit using PE and Informality

	(1)	(2)	(3)	(4)	(5)
Variables	**All firms & surveys**	**All firms in LACES**	**No DR in LACES**	**Panel firms in LACES**	**All firms in PROTEqIN**
PE	−2.7810 (2.614)	25.0997*** (4.751)	24.4683*** (4.880)	34.1475*** (6.056)	12.4114 (8.087)
PE squared	1.5290 (1.207)	−10.5438*** (2.105)	−9.8402*** (2.152)	−14.0899*** (2.622)	−4.9305 (3.670)
Informality	0.1249** (0.060)	0.2185** (0.089)	0.1931* (0.102)	0.1576 (0.119)	−0.0874 (0.098)
Informality squared	−0.0257 (0.016)	−0.0404* (0.023)	−0.0271 (0.027)	−0.0176 (0.032)	0.0261 (0.025)
Log(size)	0.1600*** (0.023)	0.0847** (0.034)	0.0700* (0.040)	0.1093** (0.045)	0.2932*** (0.038)
Log(age)	−0.0237 (0.038)	−0.0446 (0.052)	−0.0293 (0.058)	−0.0343 (0.068)	0.0569 (0.068)
Export	0.3527*** (0.059)	0.4618*** (0.094)	0.5009*** (0.103)	0.4459*** (0.118)	0.3212*** (0.088)
Multinational	−0.0035 (0.080)	−0.1305 (0.121)	−0.0903 (0.135)	0.0951 (0.154)	0.0237 (0.124)
Internal funds	0.8210*** (0.060)	1.5365*** (0.098)	1.3187*** (0.108)	1.2625*** (0.128)	0.0706 (0.106)
Constant	−0.5488 (1.408)	−16.5041*** (2.658)	−16.3622*** (2.756)	−21.6029*** (3.467)	–8.9129** (4.389)
Observations	4,497	2,503	2,160	1,679	1,838

Source: Authors.
Notes: Standard errors in parentheses. * Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

TABLE A4.2. Estimating Equation 1 by FE and Tobit Random Effects using PE and Informality Average

	(1)	(2)	(3)
Variables	**Balanced – FE**	**Unbalanced – Tobit RE**	**Balanced – Tobit RE**
PE	0.0086 (0.055)	−0.1910 (0.252)	−0.2079 (0.263)
PE squared	−0.0060 (0.025)	0.1002 (0.116)	0.1053 (0.122)
Informality ISIC Avg	0.0048 (0.004)	0.0300** (0.015)	0.0452*** (0.016)
Informality ISIC Avg squared	−0.0022* (0.001)	−0.0109** (0.004)	−0.0158*** (0.005)
Log(size)	−0.0009 (0.002)	0.0103*** (0.002)	0.0122*** (0.003)
Log(age)	0.0053* (0.003)	−0.0031 (0.004)	−0.0006 (0.004)
Export	0.0154*** (0.006)	0.0276*** (0.006)	0.0273*** (0.006)
Multinational	0.0312*** (0.008)	−0.0024 (0.007)	0.0114 (0.008)
Internal funds	0.0024 (0.002)	0.0626*** (0.006)	0.0465*** (0.007)
Constant	−0.0378 (0.031)	−0.0929 (0.137)	−0.0860 (0.143)
Observations	3,644	4,480	3,644
R-squared	0.0864		
Number of UNIQUEID_LACES	1,851	2,687	1,851

Source: Authors.
Notes: Standard errors in parentheses. * Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

TABLE A4.3. Estimating Equation 1 by Fixed Effects and Tobit Random Effects using PE ISIC and Informality

	(1)	(2)	(3)
Variables	**Balanced – FE**	**Unbalanced – Tobit RE**	**Balanced – Tobit RE**
PE ISIC	−0.0336 (0.228)	0.1855 (1.084)	0.6404 (1.177)
PE ISIC squared	0.0090 (0.108)	−0.1180 (0.513)	−0.3303 (0.556)
Informality	0.0044** (0.002)	0.0174*** (0.006)	0.0137** (0.006)
Informality squared	−0.0013*** (0.000)	−0.0041*** (0.001)	−0.0034** (0.002)
Log(size)	−0.0008 (0.002)	0.0106*** (0.002)	0.0124*** (0.003)
Log(age)	0.0054 (0.003)	−0.0038 (0.004)	−0.0011 (0.004)
Export	0.0165*** (0.006)	0.0286*** (0.006)	0.0275*** (0.006)
Multinational	0.0309*** (0.008)	−0.0016 (0.007)	0.0113 (0.008)
Internal funds	0.0027 (0.002)	0.0638*** (0.006)	0.0475*** (0.007)
Constant	−0.0114 (0.120)	−0.2460 (0.572)	−0.4786 (0.621)
Observations	3,644	4,480	3,644
R-squared	0.0879		
Number of UNIQUEID LACES	1,851	2,687	1,851

Source: Authors.
Notes: Standard errors in parentheses. * Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

5

Foreign Direct Investment and Innovation and Productivity in the Caribbean

Preeya Mohan, Eric Strobl, and Patrick Watson

Innovative firms are more generally technologically advanced and have higher productivity. The presence of such firms in a given country may lead to greater diversification and improved international competitiveness of the economy, resulting in sustainable long run growth and development of that country (Hall and Jones, 1999; OECD, 2009; Rouvinen, 2002; Schumpeter, 1939; Griliches, 1986; Freeman, 1994; Griffith et al., 2006; Mairesse and Mohnen, 2010). Foreign direct investment (FDI) is potentially an important channel through which innovation and productivity among local firms in host countries may be transmitted. It may serve to add directly to innovative activity locally, as well as to transfer knowledge to the host economy through positive externalities in the form of various technology and knowledge spillover effects from foreign to local firms (Görg and Strobl, 2001). These knowledge transfers and spillovers may then ultimately increase the innovation and productivity of domestic firms through their own innovation activities and absorptive capacity (Griffith, Redding, and van Reenen, 2000; Cohen and Levinthal, 1989).

This chapter investigates whether FDI boosts innovation and productivity in 13 Small Island Developing States (SIDS) in the Caribbean using Compete Caribbean's 2014 Productivity, Technology, and Innovation (PROTEqIN) survey. More precisely, the study examined the following:

- Own-firm effect of increased innovation and productivity by foreign firms operating in Caribbean SIDS
- Spillover effect on innovation and productivity for local firms in the host country due to the presence of FDI in the same or a related industry
- Foreign influence on innovation and productivity for domestic firms in the region

The effect of FDI on innovation and productivity is relevant to policy since governments in the Caribbean actively seek to attract FDI (Mohan and

Watson, 2014). Mohan, Strobl, and Watson (2014) found that foreign firms were less likely to undertake innovative activity in the region than elsewhere and that only 25 percent of innovative firms were foreign owned.

While much of the earlier literature focused on the own-firm and spillover effects of FDI on productivity, there has been increasing interest in the impact of FDI on innovation (Kathuria, 2008; Beers, 2004). Some have argued that the link between FDI and productivity is not direct, as previously assumed, but that the two are connected through innovation. In particular, some researchers have argued that FDI not only enhances productivity by directly increasing innovative activity because of the presence of foreign firms, but that it also enhances the possibility of local firms in the host country engaging in research and development (R&D) and other innovation activities. Nevertheless, foreign firms may not be willing to carry out innovative activities in host countries, and technology diffusion, knowledge transfer, and spillover effects are not automatic consequences of FDI. Such consequences require that firms be able to absorb and adopt the outside knowledge and technology. It may also require complementary assets locally and appropriate government policy.

This study differed from previous studies on foreign firms and their spillover effects. First, we looked at the impact of FDI on innovation and its consequent impact on productivity. We also used a wider definition of innovation activities. We took into account a firm's decision to invest in innovation activities. We included any action by a firm that aimed to increase its knowledge, such as new concepts, ideas, processes, or methods, as innovation activities. Further, we included R&D expenditures as well as other expenditures, such as those associated with product design, marketing, staff training, new machinery, and patents and other trademark licensing. Finally, we examined both manufacturing and service firms, since most firms operating in SIDS are service providers, while the majority of studies in the existing literature focused on manufacturers.

Literature Review

FDI and the presence of foreign firms contribute to innovation and productivity in host countries by directly increasing innovation. FDI brings technological, managerial, and marketing knowhow and allows for the transfer of advanced foreign technology to host countries (Dunning, 1994; Lall, 1992). Foreign firms have internal incentives to directly transfer knowledge and technology across countries and to share technology between parent companies and their subsidiaries (Markusen, 2002). FDI injects funds into the local economy for innovation, which is costly and risky. Additionally, foreign firms may carry out R&D and set up research labs in host countries, which has the potential to increase the research capabilities and technological inputs of those host countries (Pearce, 1999).

FDI can also contribute to innovation and productivity through foreign influence on domestic firms. Technology transfer may result from the use of imported machinery, equipment, and materials by local firms operating in the host country. Using materials and inputs from foreign suppliers or selling output from foreign producers may enable local firms to produce a higher quality output and more efficiently use resources.

Spillover effects from FDI, which may take the form of horizontal or vertical spillovers, can also contribute to innovation and productivity in host countries (Griliches, 1992; Crespo and Fontoura, 2007; Görg and Greenaway, 2004; Meyer and Sinani, 2009; Smeets, 2008; Wooster and Diebel, 2010). Horizontal technology spillovers occur when foreign firms invest in domestic firms in the same industry in the same country through demonstration effects and the movement of trained labor (Caves, 1974; Fosfuri, Motta, and Ronde, 2001). Vertical technology spillovers occur through forward and backward linkages between foreign firms and local suppliers and customers within the value chain (Javorcik, 2004; Pietrobelli and Rabellotti, 2007; Pietrobelli and Saliola, 2008). These knowledge spillovers can be transferred through the supply chain (Saxenian, 1991; Breschi and Lissoni,

2001); joint ventures (Almeida and Fernandes, 2006; Lane, Salk, and Lyles, 2001); mobility of skilled labor (Cheung and Lin, 2004; Almeida and Kogut, 1999; Motta, Fosfuri, and Ronde, 1999; Kim, 1997; Greenaway, Upward, and Wright, 2002); demonstration effects (Blomstrom and Kokko, 1998; Cheung and Lin, 2004); innovation management (Aghion and Tirole, 1994; Bessant, Caffyn, and Gilbert, 1996; Cosh, Fu, and Hughes, 2004); and competitive pressure (Geroski, 1990; Dunning and Lundan, 2008; Aitken and Harrison, 1999; Aghion et al., 2005; Fu, 2004, 2007; Cohen and Levin, 1989; Symeonidis, 2001; Hu and Jefferson, 2002).

Nevertheless, FDI may not always increase the innovation and productivity of local firms. First, foreign firms may choose not to innovate in host countries, but to instead use them as outlets to expand operations and sales since foreign firms have access to innovation and technology through their parent companies and because innovation activities are risky, with high sunk costs and gestational lags (Beers, 2004; Kathuria, 2008). Also, technologically advanced foreign firms have positive effects on innovation only if local firms are sufficiently close to the technology frontier (Aghion et al., 2009; Acemoglu, Aghion, and Zilibotti, 2006). Further, spillovers from FDI only occur if there are local firms and research institutions with sufficient R&D and absorptive capacity (Cohen and Levinthal, 1989; Girma, 2005; Teece, 1986; Teece, Pisano, and Shuen, 1997; Cosh, Fu, and Hughes, 2005; Cantwell and Piscitello, 2002; Cantwell and Santangelo, 1999; Aghion and Howitt, 1992, 1998; Griffith, Redding, and van Reenen, 2003). In addition, there must be effective linkages between foreign and domestic firms and research institutions (Balasubramanyam, Salisu, and Sapsford, 1996). Furthermore, the technology gap between domestic and foreign firms must not be too large (Glass and Saggi, 1998; Aghion and Griffith, 2005; Kokko, 1996; Meyer, 2004). Trade openness also facilitates linkages and directs resources to the right sectors, creating a competitive and dynamic environment (Balasubramanyam et al., 1996; Aitken and Harrison, 1999). Lastly, foreign firms will not bring core technology into their subsidiaries or carry out innovation activities in countries with weak intellectual property protection (Pietrobelli and Saliola, 2008).

Empirical studies of the benefits of FDI to innovation and productivity in host countries have provided mixed findings and therefore the impact of FDI remains inconclusive. Several studies of firms in the manufacturing and service sectors in various countries have found that FDI and foreign ownership positively affected innovative activity and productivity. Firms operating locally with foreign investors have more researchers and learn more from more sources such as suppliers and customers, universities and their intra-firm global information (Love, Ashcroft, and Dunlop, 1996; Erdilek, 2005; Wagner, 2006; Blind and Jungmittag, 2004; Bertschek, 1995; Lofts and Loundes, 2000; Masso, Roolaht, and Varblane, 2010; Griffith, Redding, and van Reenen, 2004; Criscuolo, Haskel, and Slaughter, 2005). Other studies have shown that FDI may have no effect on innovation (Lööf, Ebersberger, and Jahansson, 2006; Balcet and Evangelista, 2005; Bertrand and Zuñiga, 2006; Almeida and Fernandes, 2006; Falk and Falk, 2006; Bishop and Wiseman, 1999).

Studies from developed and developing countries have shown that FDI spillovers lead to substantial productivity gains and increased innovation activities by domestic firms (Keller and Yeaple, 2009; Javorcik, 2004; Zhang et al., 2009; Liu and Zou, 2008; Chang and Xu, 2008; Girma and Görg, 2007; Sinani and Meyer, 2004; Vahter, 2010; Eden, Levitas, and Martinez, 1997; Kokko, 1996; Buckley, Clegg, and Wang, 2002; Haskel, Pereira, and Slaughter, 2007). Other studies have found no positive spillover effects on innovation and productivity (Damijan and Knell, 2005; Vahter and Masso, 2007; Haddad and Harrison, 1993; Zukowska-Gangelmann, 2000). Lastly, studies have found a negative impact of FDI spillovers on innovation and productivity in local firms (Djankov and Hoekman, 1998; Girma, Gong, and Görg, 2006; Aitken and Harrison, 1999; Sasidharan, 2006; Fu, 2008, 2004; Zhou, 2006).

Methodology and Data

The Econometric Model

The econometric model was adapted from Crépon, Duguet, and Mairesse (1998) (the CDM model). Crépon et al. (1998) were the first to study the relationship between innovation and productivity using a recursive equation system based on innovation inputs and outputs, where this relationship was originally proposed by Pakes and Griliches (1984). The model was further developed by Crespi and Zuñiga (2012) to include a wider measure of innovative activity based not only on a firm's R&D decision and expenditures, but also on expenditures on other innovative activities, such as product design, staff training, and purchasing new equipment.

The model is a system of five equations that link a firm's R&D expenditures to its innovation output and its innovation output to its productivity. We extended the model by employing three foreign-related and spillover factors as explanatory variables: ownership of the firm (foreign or local), the share of total employment by foreign-owned firms within a given industry, and the use of material inputs of foreign origin by domestic firms. These added variables made it possible to investigate whether FDI and the presence of foreign firms contributed to innovation and productivity in host countries by directly increasing innovation through spillovers and through foreign influence.

The model was estimated in three steps. First, we used a two-equation system to model (1) a firm's decision to innovate and (2) the size of the innovation effort. Both equations used a generalized Tobit model and were estimated by maximum likelihood. Equation 1 was used to indicate whether a firm decided to undertake innovation activities or not and employed an observable indicator function (*ID*) that took the value of 1 if a firm carried out innovation activities, and 0 otherwise. Equation 1 also used various explanatory variables that might have affected a firm's decision to undertake innovation activities, such as firm size, and sundry variables to reflect whether or not a firm received public funding, benefited from patent protection, exported its products, had an R&D department, or faced competition within the industry. These variables are explained in the Appendix.

$$ID_i = 1 \text{ if } ID_i^* = w_i'\alpha + e_i > 0, \quad 0 \text{ if } ID_i^* = w_i'\alpha + e_i 0 \qquad (1)$$

where ID^* is a latent variable, w is a vector of variables influencing the innovation investment decision, including the FDI variables, α is a vector of parameters of interest,[1] and e is the error term.

Equation 2 explains a firm's innovation intensity. Conditional on firm i engaging in innovation activities, we observed the amount of resources invested in innovation (IE) activities:

$$IE_i = IE_i^* = z_i' \beta + \varepsilon i \text{ if } ID_i = 1 \; IE_i = 0 \text{ if } ID_i = 0 \qquad (2)$$

where IE^* is a latent variable representing a firm's innovative effort, z' is a set of determinants of innovation expenditures, and ε is the error term. The foreign ownership, FDI spillover, and influence variables were included, as well as other explanatory variables indicating whether or not the firm exported, benefited from patent protection, co-operated on R&D, faced competition, had an R&D department, or benefited from public financial support.

Assuming the error terms e and ε were bivariate normal with a zero mean, variances $\sigma_\varepsilon^2 = 1$ and σ_e^2 and correlation coefficient $\rho_{\varepsilon e}$, the system comprising Equations 1 and 2 was estimated as a generalized Tobit model by maximum likelihood.

The second step in the estimation exercise involved estimating Equation 3, which links innovative activity to innovation output with an innovation/knowledge production function, using the predicted values of the innovation effort from step one as one of the independent variables.

$$TI_i = IE_i^*\gamma + x_i' \delta + u_i \qquad (3)$$

[1] Ideally the knowledge spillover variable should be lagged given that what foreign firms do in the period t–1 would affect what local firms do in t; however, this data was not available.

where *TI* is a binary variable equal to 1 if there were knowledge outputs, and 0 otherwise. This variable measured the knowledge output of a firm resulting from its innovation activities (introduction of a new product or process) and knowledge spillover effects. The predicted value of the innovation effort, *IE**, from step one is entered as an explanatory variable, *x* is a vector of other determinants of knowledge production, γ and δ are vectors of parameters of interest, and *u* is an error term. The explanatory variables included in *x* are firm size and the firm's exporting status, as well as the foreign ownership and FDI spillover and influence variables. Equation 3 was estimated as a Probit model, with the predicted value of log innovation expenditures as the main explanatory variable rather than reported innovation efforts. Importantly, this corrected for potential endogeneity in the knowledge production equation.

The final step in the estimation exercise was the output production function/productivity equation, which links the firm's innovation output to productivity by including it as an input in an augmented Cobb-Douglas production function. Equation 4 was estimated using the predicted values from the Probit model in the second step since they accounted for endogeneity of the innovation output variables. We assumed that a firm's productivity depended on its own investment and external knowledge. Firms produce output on a constant returns-to-scale basis, with labor, capital, and knowledge inputs as follows:

$$y_i = \theta_i k_i + \theta_2 TI_i + v_i \qquad (4)$$

where output *y* is labor productivity, measured as log of sales per worker; *k* is capital, measured as the log of physical capital per worker (with physical investment per worker as the proxy); *TI* refers to the impact of technological innovation on productivity levels predicted from Equation 3; and v is the error term. Other independent variables are firm size, the firm's exporting status, and the foreign ownership and FDI spillover and influence variables.

Data

We used the data from Compete Caribbean's PROTEqIN survey, which was carried out in 2014 at the firm level in 13 Caribbean countries: Antigua and Barbuda, the Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, Saint Lucia, St. Kitts and Nevis, St. Vincent and the Grenadines, Suriname, and Trinidad and Tobago.

The main task was to examine innovation and productivity in the Caribbean as it related to innovation activities by foreign firms operating in the region, and foreign/FDI spillovers and influence on domestic firms, while controlling for all other relevant and available factors. In this regard, we considered a firm's innovation, whether it was a product or process, as the output from its own innovative activity, including expenditures on R&D, product design, staff training, and new equipment, as well as its absorptive capacity to make use of foreign ownership, knowledge spillovers, and foreign-related variables.

To capture these FDI channels, we used three foreign-related and foreign spillover and influence variables available in the PROTEqIN data:

1. *Foreign ownership*, which is a measure of ownership of firms by foreigners and gives the own-firm effect of FDI (since foreign firms contribute to innovation and productivity in host countries by directly increasing innovation intensity). Foreign ownership may also be used as a proxy for intra-firm spillovers from FDI, since FDI may also impact firm innovation and productivity more indirectly through spillover effects.
2. *The share of total employment by foreign-owned firms within a given industry* as a proxy for foreign presence in the sector and to reflect the degree of intra-industry, or horizontal technology/knowledge spillovers, from the presence of FDI in other companies in the same industry.
3. *The use of material inputs of foreign origin by domestic firms* to measure foreign influence on local firms.

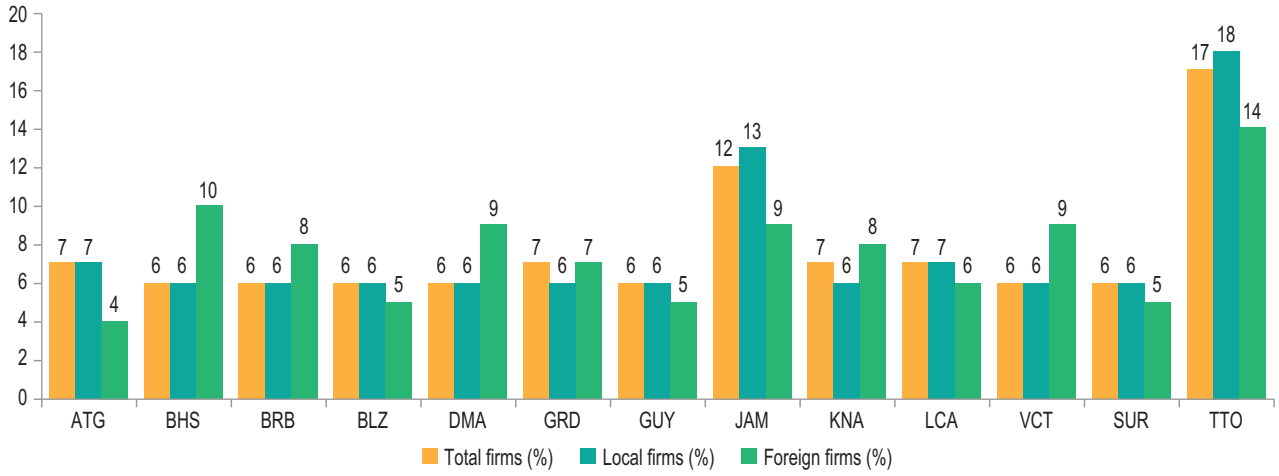
Results

Descriptive Analysis

Of the 1,966 firms in the PROTEqIN survey, only 16 percent were foreign owned. Figure 5.1 shows that Trinidad and Tobago had the largest number of foreign firms (14 percent of all foreign firms), followed by the Bahamas (10 percent), and Dominica and Jamaica (9 percent). Countries with the fewest foreign firms were Antigua and Barbuda (4 percent), Guyana and Suriname (4.5 percent), and Belize (5 percent).

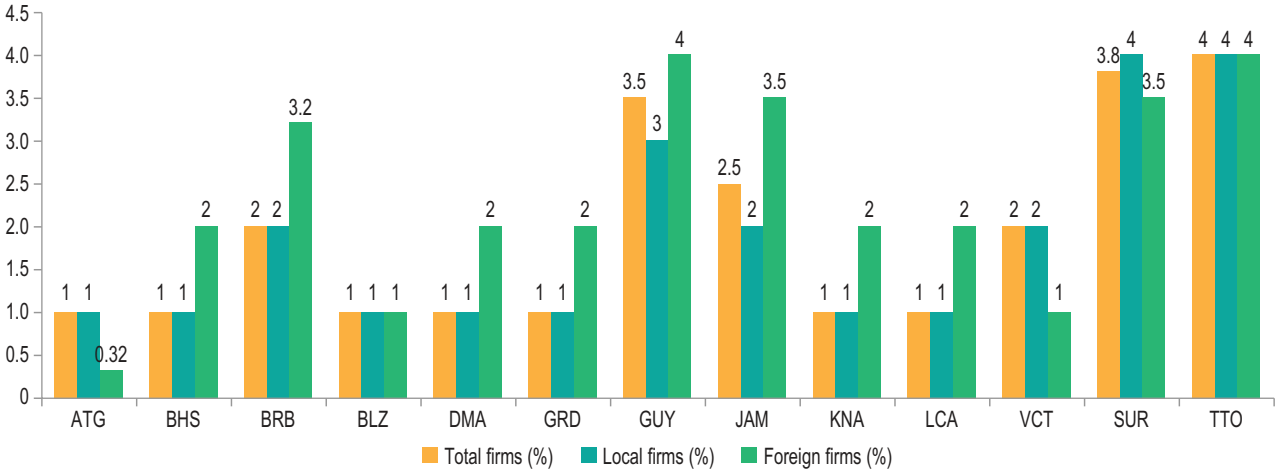
Only 26 percent of the firms surveyed engaged in innovation activities. Figure 5.2 shows that Trinidad and Tobago had the highest number of innovative firms (4 percent of all firms surveyed) followed by Suriname (4 percent), Guyana (3.5 percent), and Jamaica (2.5 percent). Countries with the fewest innovative firms (less than 1.3 percent of all firms surveyed) were Antigua and Barbuda, Belize, Dominica, Grenada, St. Kitts and Nevis, and Saint

FIGURE 5.1. Percentage of Local and Foreign Firms in Caribbean Countries



Source: Authors' calculations based on PROTEqIN data.

FIGURE 5.2. Percentage of Innovative Local and Foreign Firms in Caribbean Countries



Source: Authors' calculations based on PROTEqIN data.

Lucia. Only 19 percent of innovative firms were foreign owned. In all countries, the proportion of innovative firms that were locally owned was far higher than those which were foreign owned. Trinidad and Tobago had the highest number of foreign-owned innovative firms, (0.66 percent of all firms surveyed), followed by Guyana with (0.61 percent), Jamaica and Suriname (0.56 percent), and Barbados (0.51 percent). Antigua and Barbuda had just one firm that was both innovative and foreign owned.

Table 5.1 presents the main characteristics of foreign and local firms. Firm size was measured by the number of employees, where a small firm had less than 20 employees, a medium firm had between 20 and 99 employees, and a large firm had 100 or more employees. Table 5.1 shows that 26 percent of the foreign-owned companies were large compared to 12 percent of local firms, whereas 45 percent of foreign firms and 37 percent of local firms were medium sized. On the other hand, a large share of local firms were small (51 percent) compared to foreign firms (29 percent). Therefore, it appears that foreign firms are generally larger than domestic firms in the Caribbean. In terms

TABLE 5.1. Characteristics of Foreign and Local Firms

	Local firms		Foreign firms	
Firm characteristics	**#**	**%**	**#**	**%**
Size (number of employees)				
Small (< 20 employees)	846	51	91	29
Medium (≥ 20 and < 100)	617	37	140	45
Large (≥ 100)	192	12	80	26
Exporter/non-exporter				
Exporter	305	18	108	35
Non-exporter	1,350	82	203	65
Industry				
Manufacturing	553	33	107	34
Other manufacturing	153	9	21	7
Food	161	10	35	11
Textiles	4	0	2	0.5
Garments	35	2	6	2
Chemicals	38	2	13	4
Plastics and rubber	16	1	2	0.5
Non-metallic mineral products	39	2	10	3
Basic metals	24	2	3	1
Fabricated metal products	30	2	5	2
Machinery and equipment	41	2	4	1
Electronics	12	1	6	2

(continued on next page)

TABLE 5.1. Characteristics of Foreign and Local Firms *(continued)*

	Local firms		Foreign firms	
Firm characteristics	**#**	**%**	**#**	**%**
Services	1,102	67	204	66
Construction	123	7	13	5
Services for motor vehicles	72	4	6	2
Wholesale	80	5	15	5
Retail	409	25	57	18
Hotel and restaurants	257	16	82	26
Transport	127	8	27	9
Information technology	34	2	4	1
Part of a larger firm				
Yes	241	15	95	31
No	1,414	85	216	69
Gender of top management				
Male	1,279	77	256	82
Female	376	23	55	18
Competitors				
Registered/formal firms				
None	13	1	3	1
1	17	1	6	2
2–5	323	19	70	22
>5	1,302	79	232	75
Unregistered/informal firms				
Yes	1,018	62	127	41
No	637	38	184	59

Source: Authors' calculations based on PROTEqIN data.

of exports, foreign firms had the larger share of exporters at 35 percent, while only 18 percent of local firms exported. Foreign firms were more likely to be part of a larger organization at 31 percent, compared to local firms at 15 percent. For gender of top management, 23 percent of local firms had a female manager compared to 18 percent of foreign firms.

To assess the extent to which local and foreign firms differed with respect to economic sector, we used two different levels of aggregation. First, we explored the percentage of firms in manufacturing as opposed to services. A larger percentage of firms, both foreign (66 percent) and local (67 percent), were in services than in manufacturing. Then, we looked at the 18 sector classification used in

the PROTEqIN survey and found only very minor differences between local and foreign firms. For local firms, the sectors with the largest number of firms were retail (25 percent), hotel and restaurant (16 percent), food (10 percent), other manufacturing (9 percent), and transport (8 percent). For foreign firms, the sectors with the largest number of firms were hotel and restaurant (26 percent), retail (18 percent), food (11 percent), transport (9 percent), and other manufacturing (7 percent). In the information technology sector, local firms had a slightly higher proportion of firms (2 percent) compared to foreign firms (1 percent), which was somewhat surprising.

We also examined the intensity of competition faced by local and foreign firms from registered (formal) and unregistered (informal) businesses. Both local and foreign firms reported a relatively high level of competition from registered businesses, with 79 percent of local firms stating that they faced more than five competitors (the largest category in the survey) compared to 75 percent of foreign firms. With regard to informal competition, the PROTEqIN data showed that local and foreign firms were affected differently. A larger proportion of local firms reported that they faced informal competition, at 62 percent, compared to 41 percent of foreign firms.

Tables 5.2 and 5.3 provide some preliminary evidence about the relationship between FDI, innovative activity, and innovative output for Caribbean firms. Table 5.2 displays differences between foreign and local firms in terms of various innovative inputs, including spending on innovation, the existence of an R&D department, co-operation on innovation, the use of licensed technology, and patents. The proportion of foreign firms undertaking each of these activities was higher than that of local firms. In terms of innovation expenditures, 24 percent of foreign firms responded that they funded an innovation activity, while the corresponding figure for local firms was just 18 percent.

TABLE 5.2. Innovation Input Indicators by Foreign and Local Firms

	Local firms		Foreign firms	
Variable	**#**	**%**	**#**	**%**
Innovation expenditure	295	18	74	24
R&D department	165	10	36	12
Co-operate on innovation	204	12	47	15
Supplier	19	1	8	3
Client	15	0.5	2	0.5
Competitor	13	0.5	2	0.5
Other company in sector	59	4	14	4
Laboratory	50	3	9	3
University	46	3	12	4
Parent company	1	0	—	—
Consultant	1	0	—	—
Licensed technology	205	12	46	15
Patents	80	5	28	9

Source: Authors' calculations based on PROTEqIN data.

TABLE 5.3. Innovation Output by Foreign and Local Firms

Innovation output	Local firms		Foreign firms	
	#	%	#	%
Product	342	21	76	24
Process	198	12	53	17
Marketing	227	14	47	15
Organizational	152	9	31	10

Source: Authors' calculations based on PROTEqIN data.

Among foreign firms in the survey, 12 percent had an R&D department, while the figure for local firms was 10 percent. When looking at co-operation on innovation, 15 percent of foreign firms co-operated, while 12 percent of local firms co-operated. Foreign firms co-operated mostly with other firms in the sector and universities (4 percent each). Local firms co-operated mostly with other companies in the sector (4 percent). Among foreign firms, 15 percent used a licensed technology compared to 12 percent of local firms, and 9 percent owned patents compared to 5 percent of local firms.

Table 5.3 shows the differences between the innovation output—product, process, marketing, and organizational innovations—of foreign and local firms. A higher percentage of foreign firms than local firms reported innovation output in all four categories. Product innovations were the most common, with 24 percent of foreign firms and 21 percent of local firms responding that they had an innovative product. The percentage of firms with process and marketing innovations was similar, with 17 percent of foreign firms and 12 percent of local firms having a process of innovation, and 15 percent of foreign firms and 14 percent of local firms having a marketing innovation. Organizational innovations were the least common, at 10 percent for foreign and 9 percent for local firms.

Table 5.4 provides summary data on cost, knowledge, market, and policy barriers to innovation activities for local and foreign firms. In general, innovation barriers appear to affect a larger proportion of local firms compared to foreign firms:

- 70 percent of local firms and 67 percent of foreign firms experienced cost barriers;
- 91 percent of both local and foreign firms experienced knowledge barriers;
- 52 percent of local firms and 50 percent of foreign firms experienced market barriers; and
- 83 percent of both local and foreign firms experienced policy barriers.

Further, local firms reported that direct public funding and the flexibility/openness of other companies in the sector to collaboration were major and severe barriers to innovation (49 percent each), followed by protection against copycats (46 percent), and time to market (45 percent). Similarly, the barriers that affected the largest proportion of foreign firms were direct public funding (49 percent), flexibility/openness of other companies in the sector to collaboration and protection against copycats (47 percent), and time to market (44 percent).

Econometric Results

The econometric results for the modified CDM model are provided in Tables 5.5, 5.6, and 5.7. Three separate regression specifications were used, each containing one of the following FDI or foreign-related variables:

- Foreign ownership;
- The sectoral share of foreign employment to total industry employment using PROTEqIN's 18 sector classification; or
- The use of foreign inputs by domestic firms.

Column 1 in all three tables provides the results for the foreign ownership variable and includes both domestic and foreign firms since it investigates innovation and productivity of foreign firms operating in the region and their spillover effects on domestic firms. Column 2 in all three tables provides the results for the share of employment by foreign

TABLE 5.4. Innovation Barriers: Local versus Foreign Firms

	Local firms		Foreign firms	
Barriers	**#**	**%**	**#**	**%**
Financing and costs				
Level of available financial resources	714	43	126	41
Direct public funding for innovation	804	49	151	49
Total	**1,152**	**70**	**207**	**67**
Knowledge				
Qualification of employees	590	36	118	38
Technical uncertainties	545	33	90	29
Level of information about available technologies	371	22	68	22
Level of information about new trends in the market	599	36	113	36
Linkages with public universities and tertiary institutions	617	37	120	39
Technical capacity in key institution responsible for innovation promotion	355	21	70	23
Flexibility/openness of laboratories/research centers to collaborative approaches	707	43	116	37
Flexibility/openness of other companies in the sector to collaborative approaches	819	49	145	47
Total	**1,503**	**91**	**283**	**91**
Market				
Client flexibility and openness to new goods or services	231	14	41	13
Time to market	749	45	138	44
Total	**858**	**52**	**154**	**50**
Policy and regulation				
Requirements to comply with international standards	555	34	97	31
Current organizational and managerial culture	524	32	98	32
Internal remuneration policy and incentive structure	244	15	47	15
Protection against copycats	764	46	147	47
Investment and policy framework to foster innovation	394	24	67	22
Degree of self-confidence for innovation	374	23	63	20
Total	**1,373**	**83**	**258**	**83**

Source: Authors' calculations based on PROTEqIN data.

firms as a percent of total employment. In this case, the econometric analysis included domestic firms only, since we were interested in the horizontal FDI spillover effect on domestic firms. Column 3 shows the use of foreign material inputs by domestic firms. Again the econometric analysis in this case included domestic firms only since we wanted to examine foreign influence on domestic firms. A summary of the list of variables employed in the econometric analyses and their definition is provided in the Appendix.

TABLE 5.5. Probability of Investing in Innovation (ID) and Intensity of Innovation Expenditure per Employee (IE)

	(1)	(2)	(3)
ID (probability of investing in innovation IE > 0)			
Exporting	.0729031*** (.02445)	.0615578** (.02497)	.0630961** (.02501)
Patent protection	.4321815*** (.06398)	.3953614*** (.07323)	.394894*** (.07342)
Size	.0398775*** (.00703)	.0316511*** (.00652)	.0319103*** (.00656)
R&D department	.4176615*** (.04729)	.4262314*** (.0521)	.4325312*** (.05212)
Competition	.0506155** (.02119)	.0510614** (.02005)	.0519763** (.02011)
Foreign ownership	.0100364 (.02271)		
Foreign sectoral employment		−.000109 (.00048)	
Foreign inputs			−.0307288 (.03376)
IE (log innovation expenditure per employee)			
Exporting	.4730923*** (.16171)	.3854548** (.16668)	.3970267** (.16697)
Patent protection	2.61746*** (.38767)	2.407507*** (.44894)	2.405595*** (.44992)
Co-operation in R&D	−.0027935 (.02576)	−.0081837 (.02355)	−.0091267 (.02348)
Public support	.0099204 (.03019)	.0211456 (.02687)	.0228003 (.02684)
R&D department	2.608157*** (.31044)	2.740001*** (.35353)	2.782963*** (.35575)
Competition	.3549834*** (.13493)	.3637849*** (.12959)	.369543** (.13013)
Foreign ownership	.0800477 (.1479)		
Foreign sectoral employment		−.0009434 (.00331)	
Foreign inputs			−.2179763 (.22539)
Observations	1,966	1,655	1,655
Wald-Test	123.14***	105.68***	105.16***
Wald test of independence ()	37.62***	31.90***	29.23***
Log pseudo likelihood	−1221.012	−994.7476	−994.2748

Source: Authors.
Notes: Coefficients reported are marginal effects. Robust standard errors in parentheses. *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

The decision to invest in innovation and the intensity of innovation expenditures

Table 5.5 presents the results of the estimation of the Heckman equation with a selection model for a firm's engagement in innovation activities and the outcome equation for the intensity of innovation expenditures as the log of innovation expenditure per employee for foreign ownership, the sectoral share of foreign employment, and the use of foreign inputs by domestic firms. The reported estimates are the marginal effects.

Table 5.5 shows that, for all three econometric specifications (foreign ownership, sectoral share of foreign employment, and use of foreign materials by domestic firms), the traditional determinants that increase the likelihood of a firm deciding to engage in innovation activities were firm size, whether the firm exported, the existence of an R&D department, competition from other firms, and whether or not the firm benefited from patent protection. Thus, firms that exported, had an R&D department, faced competition, had patents, and were larger were more likely to carry out innovation activities. All three FDI/foreign-related variables were insignificant. The results therefore suggest that foreign ownership, which measures own-firm innovative effort by foreign firms in the host country and acts as a measure of intra-firm spillover from foreign to domestic firms, does not influence a Caribbean firm's decision to innovate. The insignificant coefficient for the sectoral share of foreign employment indicates that horizontal FDI spillover (i.e., stronger competitive pressure or knowledge flows from FDI firms to other firms that result from the mobility of labor and demonstration effects) did not influence a domestic firm's decision to innovate. Similarly, the insignificant coefficient for the use of foreign inputs by domestic firms suggests that foreign influence did not affect a firm's decision to innovate in the Caribbean.

Examining the results of the determinants of log innovation expenditures per employee revealed that exporting, having an R&D department, competition from other firms, and patent protection were significant, and as such predicted innovation expenditures. On the other hand, public financial assistance and cooperation on innovation did not seem to predict innovation expenditures. Again, the three FDI variables were insignificant determinants of firm innovation expenditures in the Caribbean (Table 5.5, columns 1, 2, and 3). Hence, own-firm innovative effort and intra-firm spillover from foreign to domestic firms, horizontal FDI spillover from foreign to domestic firms, and foreign influence did not affect innovation expenditures.

The impact of innovation investment on the probability of technological innovation

Table 5.6 provides the summary results for the estimation of the knowledge production function for a product and process innovation dummy variable that was used as the technological innovation output variable for foreign ownership (column 1), foreign sectoral employment (column 2), and the use of foreign inputs by domestic firms (column 3). The coefficients reported are the marginal effects. Accordingly, the results in columns 1, 2, and 3 illustrate that those Caribbean firms that spent more on innovation were more likely to introduce a product or process innovation. More specifically, as the coefficient on the predicted innovation expenditure shows, a unit increase in log innovation expenditure per employee increased the probability of technological innovation by about 52 percent when the foreign ownership variable was used, 43 percent for the sectoral share of foreign employment variable, and 42 percent for the use of foreign inputs by domestic firms variable. Additionally, results showed that the larger the firm, the higher the probability of introducing a product or process innovation.

The coefficient for foreign ownership was negative and significant (Table 5.6, column 1), which suggests that foreign ownership reduces the probability of implementing a product or process innovation. A foreign-owned firm was 6 percent less likely to introduce a technological innovation. It is likely that foreign firms operating in the Caribbean choose not to innovate locally, but instead to use the region as an outlet to expand operations and sales since foreign firms have access to innovation

TABLE 5.6. Probability of Technological Innovation (TI: introduction of product or process innovation)

	(1)	(2)	(3)
IE_p (predicted Innovation expenditure per employee)	.5248787*** (.0349948)	.4260891*** (.0350188)	.4180566*** (.0353951)
Size	.0396761*** (.0106294)	.0370767*** (.0111468)	.0370892*** (.0112551)
Exporting	−.0166701 (.1176991)	.0320624 (.2329404)	.0089583 (.0328308)
Foreign ownership	−.0601588** (.0283003)		
Foreign sectoral employment		.0009751 (.0007535)	
Foreign inputs			.0918117* (.0350373)
Observations	1,966	1,655	1,655
Wald	463.05***	330.88***	345.47***
Log pseudo likelihood	−732.33003	−635.19222	−637.69617
Pseudo R^2	0.3468	0.3161	0.3134
Observed probability	.2573754	.2489426	.2489426
Predicted probability (values at means)	.2286034	.2175168	.2173379

Source: Authors.
Notes: Coefficients reported are marginal effects. Robust standard errors in parentheses. *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

and technology through their parent companies and because innovation activities are risky, with high sunk costs and gestational lags. Thus, foreign firms have to be willing to bring core technologies into their subsidiaries and to carry out innovation activities. They may be unwilling to do so in developing countries with weak intellectual property protection, such as in Caribbean SIDS.

On the other hand, the use of foreign material inputs by domestic firms was positive and significant, meaning that domestic firms that used foreign inputs were more likely to introduce a product or process innovation. Foreign technology transfer into the Caribbean is therefore likely a result of local firms using imported machinery, equipment, and materials since there is sufficient trade openness to facilitate these types of linkages. The results show that a firm that used foreign inputs was 9 percent more likely to undertake technological innovation.

The share of foreign sectoral employment did not significantly affect a firm's technological innovation. The presence of FDI in the industry was therefore not associated with an increase in innovation output because of stronger competitive pressures and knowledge flows from labor mobility and demonstration effects. Positive spillover effects on innovation from foreign to local firms occur only if local firms are sufficiently close to the technology frontier; the technology gap between foreign and domestic firms is not too large; there is sufficient R&D, absorptive capacity, and complementary assets in the way of local firms and research institutions; and there are effective linkages between foreign and domestic firms and research institutions. These may not be present in the Caribbean.

The impact of innovation on productivity

Finally, Table 5.7 shows the results of the productivity equation, where the coefficients were reported as elasticities or semi-elasticities since the dependent variable was the log of sales per employee. Here we found that firm size positively affected labor productivity in all three regression specifications. Similarly, non-technical innovation had a positive and significant impact on labor productivity in all three regression specifications; however, this result must be considered cautiously. Unlike with technological innovation, we assumed no selection bias and no endogeneity for non-technical innovation. We found that innovation expenditures did not have a significant impact on labor productivity in any of the three regressions. Finally, foreign ownership and the sectoral share of foreign employment did not have a significant impact on labor productivity; however, the use of foreign inputs positively affected labor productivity.

Conclusions

FDI is a key channel that can potentially increase innovation and productivity among local firms in host countries. It increases the possibility of local firms in the host country engaging in R&D and other innovation activities and benefiting from various technology and knowledge transfer and spillover effects. However, the empirical evidence about FDI, innovation, and productivity is mixed and inconclusive since technology diffusion, knowledge transfer, and spillover effects are not an automatic consequence.

This chapter investigated whether FDI and its spillover effects boosted innovation and productivity in firms in 13 Caribbean SIDS using Compete

TABLE 5.7. The Impact of Innovation on Labor Productivity (Y: log sales per employee)

	(1)	(2)	(3)
IE_p (predicted Innovation expenditure per employee)	.0484124 (.1151089)	.0829141 (.1154168)	.0561747 (.1145323)
Size	.0978239** (.0417294)	.1022162*** (.0390586)	.0913619** (.0394309)
Non-technological innovation	268.508** (109.4622)	262.9089* (150.2173)	291.1912* (153.6217)
Capital per employee	−268.050** (109.4445)	−262.4613* (150.1888)	−290.7403* (153.5936)
Foreign ownership	.0180618 (.120428)		
Foreign sectoral employment		.0006529 (.0028058)	
Foreign input			.4955465* (.267978)
Observations	1,966	1,655	1,655
Wald test	969.56***	514.18***	549.18***
R^2	0.1576	0.1547	0.1397

Source: Authors.
Notes: Bootstrapped standard errors in parentheses (100 replications). The variable used as a proxy for physical capital was investment made during the period considered the stock of physical capital. *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

Caribbean's 2014 PROTEqIN survey. The data indicated that foreign firms operating in the Caribbean were generally larger than domestic firms, were more likely to be exporters and part of a larger organization, and were less likely to face informal competition. Additionally, while we might have expected that a larger number of foreign firms would operate in knowledge intensive services, the data showed that local firms had a slightly higher proportion of firms in the information technology sector compared to foreign firms.

The data also showed that the proportion of innovative foreign firms in the Caribbean was quite low. Of the 506 firms that were innovative, only 19 percent were foreign owned, the other 81 percent being locally owned. Moreover, in all 13 Caribbean countries in the study, the proportion of innovative firms that were locally owned was far higher than the proportion of innovative firms that were foreign owned. However, the proportion of foreign firms that engaged in innovation activities (spent on innovation, had an R&D department, cooperated on innovation, used a licensed technology, or had patents) was higher than local firms. Also, a higher proportion of foreign firms had innovative outputs (product, process, market, or organizational innovation) compared to local firms. Further, cost, knowledge, market, and policy barriers affected a larger proportion of local firms than foreign firms.

The econometric results suggest that own-firm innovative effort by foreign firms in the host country and intra-firm spillover from foreign to domestic firms do not influence a Caribbean firm's decision to innovate. Also, horizontal FDI spillover (i.e., stronger competitive pressure or knowledge flows from FDI firms to other local firms from the mobility of labor and demonstration effects) do not influence a domestic firm's decision to innovate. Foreign influence also does not affect a firm's decision to innovate in the Caribbean. Similarly, own-firm innovative effort and intra-firm spillover from foreign to domestic firms, horizontal FDI spillover from foreign to domestic firms, and foreign influence do not affect innovation expenditures.

The econometric results also show that foreign ownership reduces the probability of implementing a product or process innovation. Therefore, it is likely that foreign firms operating in the Caribbean choose not to innovate in host countries, but to instead use them as outlets to expand operations and sales since foreign firms have access to innovation and technology through their parent companies and because innovation activities are risky, with high sunk costs and gestational lags. Also, foreign firms may be unwilling to carry out innovation activities in developing countries such as the Caribbean because of weak intellectual property protection. The use of foreign material inputs increased a domestic firm's likelihood of introducing a product or process innovation. Foreign technology transfer into the Caribbean is therefore likely a result of local firms using imported machinery, equipment, and materials since there is sufficient trade openness to facilitate these types of linkages. FDI horizontal spillover effects in the industry did not increase product or process innovations by local firms. This may be because local firms in the Caribbean are not sufficiently close to the technology frontier; that the technology gap between foreign and domestic firms is too large; that there is insufficient R&D, absorptive capacity, and complementary assets in the way of local firms and research institutions; and that there are ineffective linkages between foreign and domestic firms and research institutions.

Lastly, own-firm innovation by foreign firms and intra-firm spillover and horizontal FDI spillover did not have a significant impact on labor productivity. However, foreign influence through the use of foreign inputs by domestic firms positively affected labor productivity.

References

Acemoglu, D., P. Aghion, and F. Zilibotti. 2006. "Distance to Frontier, Selection, and Economic Growth." *Journal of the European Economic Association* 4(1):37–74.

Aghion, P., N. Bloom, R. Blundell, R. Griffith, and P. Fowitt. 2005. "Competition and Innovation: An Inverted U Relationship." *Quarterly Journal of Economics* 120(2):701–28.

Aghion, P., R. Blundell, R. Griffith, P. Howitt, and S. Prantl. 2009. "The Effects of Entry on Incumbent Innovation and Productivity." *The Review of Economics and Statistics* 91(1):20–32.

Aghion, P., and R. Griffith. 2005. *Competition and Growth: Reconciling Theory and Evidence*. Cambridge, MA: MIT Press.

Aghion, P., and P. Howitt. 1992. "A Model of Growth through Creative Destruction." *Econometrica* 60(2):323–51.

——— . 1998. *Endogenous Growth Theory*. Cambridge, MA: MIT Press.

Aghion, P., and J. Tirole. 1994. "Formal and Real Authority in Organizations." Discussion Paper 37. Toulouse: Institue d'Economie Industrielle.

Aitken, B., and A. Harrison. 1999. "Do Domestic Firms Benefit from Direct Foreign Investment: Evidence from Venezuela?" *American Economic Review* 89(3):605–18.

Almeida, P., and B. Kogut. 1999. "Localization of Knowledge and the Mobility of Engineers in Regional Networks." *Management Science* 45(7):905–17.

Almeida, R., and A. Fernandes. 2006. "Openness and Technological Innovations in Developing Countries: Evidence from Firm-Level Surveys." Working Paper 3985. Washington, DC: World Bank Policy Research.

Balasubramanyam, V., M. Salisu, and D. Sapsford. 1996. "Foreign Direct Investment and Growth in EP and IS Countries." *Economic Journal* 106(434):92–105.

Balcet, G., and R. Evangelista. 2005. "Global Technology: Innovation Strategies of Foreign Affiliates in Italy." *Transnational Corporations* 14(2):53–92.

Beers, C. 2004. "Multinationals and the Knowledge Economy in Small Countries." *Economic Bulletin* 41(6):205–8.

Bertrand, O., and P. Zuñiga. 2006. "R&D and M&A: Are Cross-border M&A Different? An Investigation on OECD Countries." *International Journal of Industrial Organization* 24(2):401–23.

Bertschek, I. 1995. "Product and Process Innovation as a Response to Increasing Imports and Foreign Direct Investment." *The Journal of Industrial Economics* 43(4):341–57.

Bessant, J., S. Caffyn, and J. Gilbert. 1996. "Learning to Manage Innovation." *Technology Analysis and Strategic Management* 8(1):59–70.

Bishop, P., and N. Wiseman. 1999. "External Ownership and Innovation in the United Kingdom." *Applied Economics* 31(4):443–50.

Blind, K., and A. Jungmittag. 2004. "Foreign Direct Investment, Imports and Innovations in the Service Industry." *Review of Industrial Organization* 25(2):205–27.

Blomstrom, M., and A. Kokko. 1998. "Multinational Corporations and Spillovers." *Journal of Economic Surveys* 12(3):247–77.

Breschi, S., and F. Lissoni. 2001. "Knowledge Spillovers and Local Innovation Systems: A Critical Survey." *Industrial and Corporate Change* 10(4):975–1004.

Buckley, P., J. Clegg, and C. Wang. 2002. "The Impact of Inward FDI on the Performance of Chinese Manufacturing Firms." *Journal of International Business Studies* 33(4):637–55.

Cantwell, J., and L. Piscitello. 2002. "The Location of Technological Activities of MNCs in European Regions." *Journal of International Management* 8(1):69–96.

Cantwell, J., and G. Santangelo. 1999. "The Frontier of International Technology Networks: Sourcing Abroad the Most Highly Tacit Capabilities." *Information Economics and Policy* 11(1):101–23.

Caves, R. 1974. "Multinational Firms, Competition, and Productivity in Host Country Markets." *Economica* 41(162):176–93.

Chang, S. J., and D. Xu. 2008. "Spillovers and Competition among Foreign and Local Firms

in China." *Strategic Management Journal* 29(5):495–51.

Cheung, K., and P. Lin. 2004. "Spillover Effects of FDI on Innovation in China: Evidence from the Provincial Data." *China Economic Review* 15(1):25–44.

Cohen, W., and R. Levin. 1989. "Empirical Studies of Innovation and Market Structure." In R. Schmalensee and R. D. Willig (eds.), *Handbook of Industrial Organization*, Vol. 2. Amsterdam: Elsevier Science Publishers.

Cohen, W., and D. Levinthal. 1989. "Innovation and Earning: The Two Faces of R&D." *Economic Journal* 99(397):569–96.

Cosh, A., X. Fu, and A. Hughes. 2004. "How Much Does Informality in Management Matter for SME Innovation." Paper presented at the 35th Entrepreneurship, Innovation and Small Business (EISB) Conference, September, Barcelona, Spain.

——— . 2005. "Management Characteristics, Collaboration and Innovative Efficiency: Evidence from UK Survey Data." ESRC Centre for Business Research, Working Paper 311. Swindon: Economic and Social Research Council.

Crépon, B., E. Duguet, and J. Mairesse. 1998. "Research, Innovation and Productivity: An Econometric Analysis at the Firm Level." *Economics of Innovation and New Technology* 7(2):115–58.

Crespi, G., and P. Zuñiga. 2012. "Innovation and Productivity: Evidence from Six Latin American Countries." *World Development* 40(2):273–90.

Crespo, N., and M. Fontoura. 2007. "Determinant Factors of FDI Spillovers: What Do We Really Know?" *World Development* 35(3):410–25.

Criscuolo, C., J. Haskel, and M. Slaughter. 2005. "Global Engagement and the Innovation Activities of Firms." Working Paper 11479. Cambridge, MA: National Bureau of Economic Research.

Damijan, J., and M. Knell. 2005. "How Important Is Trade and Foreign Ownership in Closing the Technology Gap? Evidence from Estonia and Slovenia." *Review of World Economics* 141(2):271–95.

Djankov, S., and B. Hoekman. 1998. "Avenues of Technology Transfer: Foreign Investment and Productivity Change in the Czech Republic." CEPR Discussion Paper 1883. London, UK: Centre for Economic Policy Research.

Dunning, J. 1994. "Multinational Enterprises and the Globalization of Innovatory Capacity." *Research Policy* 23(1):67–88.

Dunning, J., and S. Lundan. 2008. "Theories of Foreign Direct Investment." In J. H. Dunning and S. M. Lundan (eds.), *Multinational Enterprises and the Global Economy*, pp.79–115. Cheltenham: Edward Elgar Publishing Limited.

Eden, L., E. Levitas, and R. Martinez. 1997. "The Production, Transfer and Spillover of Technology: Comparing Large and Small Multinational Multinationals as Technology Producers." *Small Business Economics* 9(1):53–66.

Erdilek, A. 2005. "R&D Activities of Foreign and National Establishments in Turkish Manufacturing." In M. Blomstrom, E. Graham, and T. Moran (eds.), *The Impact of Foreign Direct Investment on Development: New Measures, New Outcomes, New Policy Approaches*. Washington, DC: Institute for International Economics.

Falk, M., and R. Falk. 2006. "Do Foreign-Owned Firms Have a Lower Innovation Intensity than Domestic Firms?" Working Paper 275. Vienna: Austrian Institute of Economic Research (WIFO).

Fosfuri, A., M. Motta, and T. Ronde. 2001. "Foreign Direct Investment and Spillovers through Workers' Mobility." *Journal of International Economics* 53(1):205–22.

Freeman, C. 1994. "The Economics of Technical Change." *Cambridge Journal of Economics* 18(5):463–514.

Fu, X. 2004. "Limited Linkages from Growth Engines and Regional Disparities in China." *Journal of Comparative Economics* 32(1):148–64.

——— . 2007. "Trade-cum-FDI, Human Capital Inequality and the Dual Economy in China: The Signer Perspective." *Journal of Economic Change and Restructuring* 40(1/2):137–55.

——. 2008. "Foreign Direct Investment, Absorptive Capacity and Regional Innovation Capabilities: Evidence from China." *Oxford Development Studies* 36(1):89–110.

Geroski, P. A. 1990. "Innovation, Technological Opportunity, and Market Structure." *Oxford Economic Papers* 42(3):586–602.

Girma, S. 2005. "Absorptive Capacity and Productivity Spillovers from FDI: A Threshold Regression Analysis." *Oxford Bulletin of Economics and Statistics* 67(3):281–306.

Girma, S., Y. Gong, and H. Görg. 2006. "Can You Teach Old Dragons New Tricks? FDI and Innovation Activity in Chinese State-Owned Enterprises." IZA Discussion Papers 2267. Bonn, Germany: Institute for the Study of Labor.

Girma, S., and H. Görg. 2007. "The Role of the Efficiency Gap for Spillovers from FDI: Evidence from the UK Electronics and Engineering Sectors." *Open Economies Review* 18(2):215–32.

Glass, A., and K. Saggi. 1998. "International Technology Transfer and the Technology Gap." *Journal of Development Economics* 55:369–98.

Görg, H., and D. Greenaway. 2004. "Much Ado about Nothing? Do Domestic Firms Really Benefit from Foreign Direct Investment?" *World Bank Research Observer* 19:171–97.

Görg, H., and E. Strobl. 2001. "Multinational Companies and Productivity Spillovers: A Meta-analysis." *The Economic Journal* 111(475):F723–39.

Greenaway, S., R. Upward, and P. Wright. 2002. "Sectoral and Geographic Mobility of Labour Markets and Structural Adjustment." Unpublished mimeo. Nottingham, UK: University of Nottingham.

Griffith, R., E. Huergo, J. Mairesse, and B. Peters. 2006. "Innovation and Productivity across Four European Countries." *Oxford Review of Economic Policy* 22(4):483–98.

Griffith, R., S. Redding, and J. van Reenen. 2000. "Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Industries." CEPR Discussion Paper 2457. London, UK: Centre for Economic Policy Research.

——. 2003. "R&D and Absorptive Capacity: Theory and Empirical Evidence." *Scandinavian Journal of Economics* 105(1):99–118.

——. 2004. "Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Industries." *Review of Economics and Statistics* 86:883–95.

Griliches, Z.1986. "Productivity, R&D, and Basic Research at the Firm Level in the 1970s." *American Economic Review* 76(1):141–154.

——. 1992. "The Search for R&D Spillovers." *Scandinavian Journal of Economics* 94:29–47.

Haddad, M., and A. Harrison. 1993. "Are There Positive Spillovers from Direct Foreign Investment: Evidence from Panel Data for Morocco." *Journal of Development Economics* 42(1):51–74.

Hall, R., and C. Jones. 1999. "Why Do Some Countries Produce So Much More Output per Worker than Others?" *The Quarterly Journal of Economics* 114(1):83–116.

Haskel, J., S. Pereira, and M. Slaughter. 2007. "Does Inward Foreign Direct Investment Boost the Productivity of Domestic Firms?" *The Review of Economics and Statistics* 89(3):482–96.

Hu, A., and G. Jefferson. 2002. "FDI Impact and Spillover: Evidence from China's Electronic and Textile Industries." *World Economy* 38(4):1063–76.

Javorcik, B. 2004. "Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers through Backward Linkages." *The American Economic Review* 94(3):605–27.

Kathuria, V. 2008. "The Impact of FDI Inflows on R&D Investment by Medium and High-Tech Firms in India in the Post-Reform Period." *Transnational Corporations* 17(2):45–66.

Keller, W., and S. Yeaple. 2009. "Multinational Enterprises, International Trade, and Productivity Growth: Firm-Level Evidence from the United States." *Review of Economics and Statistics* 91(4):821–31.

Kim, L. 1997. *Imitation to Innovation: The Dynamics of Korea's Technological Learning*. Boston, MA: Harvard Business School Press.

Kokko, A. 1996. "Productivity Spillovers from Competition between Local Firms and Foreign Affiliates." *Journal of International Development* 8(4):517–30.

Lall, S. 1992. "Technological Capabilities and Industrialization." *World Development* 20(2):165–86.

Lane, P., J. Salk, and M. Lyles. 2001. "Absorptive Capacity, Learning and Performance in International Joint Ventures." *Strategic Management Journal* 22(12):1139–61.

Liu, X., and H. Zou. 2008. "The Impact of Greenfield FDI and Mergers and Acquisitions on Innovation in Chinese High-Tech Industries." *Journal of World Business* 43(3):352–64.

Lofts, C., and J. Loundes. 2000. "Foreign Ownership, Foreign Competition and Innovation in Australian Enterprises." Working Paper 20/00. Melbourne: Melbourne Institute of Applied Economic and Social Research.

Lööf, H., B. Ebersberger, and B. Jahansson. 2006. "Does Ownership Matter? The Impact of Foreign Takeovers on Innovation and Productivity Performance." CESIS Working Paper 69. Stockholm: Centre of Excellence for Science and Innovation Studies.

Love, J., B. Ashcroft, and S. Dunlop.1996. "Corporate Structure, Ownership and the Likelihood of Innovation." *Applied Economics* 28(6):737–46.

Mairesse, J., and P. Mohnen. 2010. "Using Innovation Surveys for Econometric Analysis." NBER Working Paper 15857. Cambridge, MA: National Bureau of Economic Research.

Markusen, J. 2002. *Multinational Firms and the Theory of International Trade*. Cambridge, MA: MIT Press.

Masso, J., T. Roolaht, and U. Varblane. 2010. "Foreign Direct Investment and Innovation in Central and Eastern Europe: Evidence from Estonia." Working Paper 67. Tartu, Estonia: Faculty of Economics and Business Administration, University of Tartu.

Meyer, K. 2004. "Perspectives on Multinational Enterprises in Emerging Economies." *Journal of International Business Studies* 34(4):259–76.

Meyer, K., and E. Sinani. 2009. "When and Where Does Foreign Direct Investment Generate Positive Spillovers: A Meta-analysis." *Journal of International Business Studies* 40(7):1075–94.

Mohan, P., E. Strobl, and P. Watson. 2014. "Innovative Activity in the Caribbean: Drivers, Benefits, and Obstacles." Working Paper Series 595. Paris: Ipag Business School. http://www.ipag.fr/fr/accueil/la-recherche/publications-WP.html.

Mohan, P., and P. Watson. 2014. "CARICOM Foreign Direct Investment Inflows." *Social and Economic Studies* 63(3&4):281–306.

Motta, M., A. Fosfuri, and T. Ronde. 1999. "Foreign Direct Investment and Spillovers through Workers' Mobility." CEPR Discussion Paper 2194. London, UK: Centre for Economic Policy Research.

OECD. 2009. *Innovation in Firms: A Microeconomic Perspective*. Paris, France: Organisation for Economic Co-operation and Development.

Pakes, A., and Z. Griliches. 1984. "Patents and R&D at the Firm Level: A First Look." In Z. Griliches (ed.), *R&D, Patents, and Productivity*, pp.55–72. Chicago, IL: University of Chicago Press.

Pearce, R. 1999. "Decentralised R&D and Strategic Competitiveness: Globalized Approaches to Generation and Use of Technology in Multinational Enterprises." *Research Policy* 28(2–3):157–78.

Pietrobelli, C., and R. Rabellotti. 2007. *Upgrading to Compete: SMEs, Clusters and Value Chains in Latin America*. Cambridge, MA: Harvard University Press.

Pietrobelli, C., and F. Saliola. 2008. "Power Relationships along the Value Chain: Multinational Firms, Global Buyers, and Local Suppliers' Performance." *Cambridge Journal of Economics* 32(6):947–62.

Rouvinen, P. 2002. "R&D-Productivity Dynamics: Causality, Lags, and Dry Holes." *Journal of Applied Economics* 5(1):123–56.

Sasidharan, S. 2006. "Foreign Direct Investment and Technology Spillovers: Evidence from the Indian Manufacturing Sector." UNU-MERIT

Working Papers 010. Maastricht: United Nations University – Maastricht Economic and Social Research Institute on Innovation and Technology.

Saxenian, A. 1991. "The Origins and Dynamics of Production Networks in Silicon Valley." *Research Policy* 20(5):423–37.

Schumpeter, J. 1939. *Business Cycles: A Theoretical, Historical, and Statistical Analysis of the Capitalist Process.* New York: McGraw-Hill.

Sinani, E., and K. Meyer. 2004. "Spillovers of Technology Transfer from FDI: The Case of Estonia." *Journal of Comparative Economics* 32(3):445–66.

Smeets, R. 2008. "Collecting the Pieces of the FDI Knowledge Spillover Puzzle." *The World Bank Research Observer* 23(2):107–38.

Symeonidis, G. 2001. "Price Competition, Innovation and Profitability: Theory and UK Evidence." CEPR Discussion Paper 2816. London, UK: Centre for Economic Policy Research.

Teece, D. 1986. "Profiting from Technological Innovations." *Research Policy* 15(6):285–306.

Teece, D., G. Pisano, and A. Shuen. 1997. "Dynamic Capabilities and Strategic Management." *Strategic Management Journal* 18(7):509–33.

Vahter, P. 2010. "Microeconomic Effects of Competition on Productivity in the EU." Doctoral dissertation. Nottingham: University of Nottingham.

Vahter, P., and J. Masso. 2007. "Home versus Host Country Effects of FDI: Searching for New Evidence on Productivity Spillovers." *Applied Economics Quarterly* 53(2):165–96.

Wagner, J. 2006. "International Firm Activities and Innovation: Evidence from Knowledge Production Functions for German Firms." Papers on Entrepreneurship, Growth and Public Policy 2006–15. Jena, Germany: Entrepreneurship, Growth and Public Policy Group, Max Planck Institute of Economics.

Wooster, R., and D. Diebel. 2010. "Productivity Spillovers from Foreign Direct Investment in Developing Countries: A Meta-regression Analysis." *Review of Development Economics* 14(3):640–55.

Zhang, C., D. Zhihua Zeng, W. P. Mako, and J. Seward. 2009. *Promoting Enterprise-Led Innovation in China*. Washington, DC: The World Bank.

Zhou, Y. 2006. "Features and Impacts of the Internationalisation of R&D by Transnational Corporations: China's Case." In *Globalization of R&D and Developing Countries*, Proceedings of the Expert Meeting, Geneva January 24–26, 2005. New York and Geneva: UNCTAD, United Nations.

Zukowska-Gagelmann, K. 2000. "Productivity Spillovers from Foreign Direct Investment in Poland." *Economic Systems* 24(3):223–56.

Appendix: Variables and Definition

Variable (abbreviation)	Definition
Technological innovation (TI):	Dummy equal to 1 if the firm introduced a product or process innovation.
Expenditures on innovation activities per employee (IE):	Firm innovation expenditures divided by the number of employees.
Productivity (Y):	Total sales divided by the number of employees.
Firm size (EM):	Number of employees.
Exporter/non-exporter (EX):	Dummy variable equal to 1 if firm exported.
Non-technological innovation (NTI):	Dummy variable equal to 1 if firm introduced marketing or organizational innovation.
Foreign ownership (FO):	Dummy variable equal to 1 if foreign capital was above 10 percent.
Patent protection (PA):	Dummy variable equal to 1 if firm had or had filed for a patent.
Research and development (R&D):	Dummy variable equal to 1 if firm had an R&D department.
Competition (COM):	Dummy variable equal to 1 if firm faced competition from industry competitors.
Co-operation (CO):	Dummy variable equal to 1 if firm collaborated on innovation.
Public funding (FIN):	Dummy variable equal to 1 if firm received public financing for innovation activities.
Capital per employee (INV):	Firm capital divided by the number of employees.

6

The Gender Gap in the Caribbean: The Performance of Women-Led Firms

Winston Moore, Andrea F. Presbitero, and Roberta Rabellotti

While several Caribbean countries have largely endorsed and ratified many United Nations conventions on gender equity—such as the 1979 Convention on the Elimination of All Forms of Discrimination against Women and the 1993 Declaration on the Elimination of Violence Against Women—there remain significant deficiencies in implementation (Bailey, 2003).

Studies on gender issues that focus on the Caribbean are scarce, but some general conclusions can be drawn from the Gender Inequality Index calculated by the United Nations Development Programme and based on gender gaps in literacy, life expectancy, and income.[1] A cursory glance at the 2014 rank of the 13 countries presented in this chapter[2] provides a very heterogeneous picture: The Bahamas ranked highest at 55th, followed by Barbados (57th) and Antigua and Barbuda (58th), with Guyana ranked lowest at 124th (Suriname ranked 103rd and Belize 101st).

In the Caribbean, the expected years of schooling for women are always higher than for men, and the percentage of the female population with at least some secondary education is also higher than for the male population (except in Suriname and Trinidad and Tobago, where the percentage of men with some secondary education is slightly higher than women).

Flabbi et al. (2014) used International Labour Organisation (ILO) data to calculate the average share of women in the labor force in the Caribbean. At 46 percent, the share was only 2 percentage points lower than in the United States and higher than the average for Latin American countries (40 percent). Nevertheless, the World Development Indicators[3] show that the average rate of female unemployment in the Caribbean is more than 5 percentage points higher than that of men. Females are also less likely to be promoted or elected into positions of authority. As reported in Flabbi et al. (2014),

[1] Data are available at http://hdr.undp.org/en/composite/GDI (accessed on January 5, 2016).

[2] Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, Saint Lucia, St. Kitts and Nevis, St. Vincent and the Grenadines, Suriname, and Trinidad and Tobago.

[3] Data are available at http://data.worldbank.org/data-catalog/world-development-indicators (accessed on January 5, 2016).

in 2012, 433 of the top 500 Latin American companies had no women senior executives and only nine had a woman CEO. This was confirmed in a report by ILO (2015) stating that in Jamaica and Saint Lucia the share of women-managers in businesses was higher than men but that women were mainly concentrated in middle management positions and under-represented in the most senior positions.

The statistics presented above suggest that, while women are well represented in the workforce, in the Caribbean there are still important disparities in top management. This chapter aims to investigate whether this under-representation is justified by poorer productivity in firms managed or owned by women. Thanks to the wealth of information available in the Productivity, Technology, and Innovation (PROTEqIN) database and following some recent evidence that showed that definitions matter when estimating the gender gap (Presbitero, Rabellotti, and Piras, 2014), this study adopted a set of more precise measures of female ownership and management of a firm than those traditionally used in cross-country investigations. Accordingly, we expected the results to differ depending on alternative (more or less restrictive) measures of gender composition in a firm's management and ownership.

The empirical analysis pooled all available countries to estimate a single model for identifying a common pattern in the Caribbean. Moreover, it investigated possible differences across countries and industries. The results showed no gender gap in performance considering the gender composition of firm ownership; however, women-managed firms were less productive than similar firms. While most of the gender gap was not explained by differences in observable characteristics, the results suggest that some firm characteristics for which there was evidence of a significant gender gap—such as size and access to financing—mattered for productivity.

The Literature on Gender Gap and Firm Productivity

There has been considerable research investigating gender differences in firm performance, using a variety of indicators, mainly focused on advanced economies (Wolfers, 2006; Smith, Smith, and Verner, 2006; Gagliarducci and Paserman, 2015; Flabbi et al., 2014). Klapper and Parker (2011) reviewed the related empirical literature and concluded that the underperformance of women-led businesses is usually explained by the lack of controls for the size or scale of the firm's operations. Of note, companies led by women are usually younger, less productive, less innovative, and operate on a smaller scale as well as in less capital-intensive and less efficient industries compared to male-led firms (Aterido, Beck, and Iacovone, 2013; Bruhn, 2009; Sabarwal and Terrell, 2008).

With a focus on Latin America and the Caribbean, Flabbi et al. (2014) analyzed a large dataset of publicly traded companies and found that companies with more female members on the board were significantly more likely to have one female among the firm's executives and that, when women were at least 30 percent of the executives, there was a positive association with firm performance, therefore confirming the existence of a "critical mass" effect (Kanter, 1977).

Ferdinand (2001) examined the factors affecting female entrepreneurship in small and cottage industries in three Caribbean countries (Barbados, Suriname, and Trinidad and Tobago). The study found that female-owned businesses dominated the microenterprise segments of retail and distribution, agriculture, and light manufacturing (e.g., textiles and garments)—activities with reduced potential for growth and profit.

Some studies (e.g., Aterido et al., 2013; Presbitero et al., 2014) have suggested that access to financing is a possible cause of the productivity gap between women- and men-led businesses. Other studies (e.g., Orser et al., 2010; Marques, 2015) have suggested that different export propensity between firms led by women and men may be a reason for the gender gap. Chen, Leung, and Evans (2015), among others, indicated that the innovative potential of a firm and the propensity to invest in research and development and introduce innovation may be affected by the gender composition

of ownership and management. Finally, women-led businesses could be at a disadvantage compared to similar men-led firms when it comes to access to government-sponsored support programs that can foster firm productivity. All of these determinants are investigated in the empirical analysis that follows to see whether women-led businesses were particularly exposed to such constraints.

Gender Gap in the Caribbean

For a broad general picture of the gender composition of ownership and management within firms, the following analysis was based on the World Bank Enterprise Survey (WBES),[4] which included 130,000 private firms in 135 countries. The survey provided two indicators:

1. The presence of at least one woman among the owners (female owner).
2. Firms where the top manager is a woman (female top manager).

While certainly informative, these two measures had some limitations. With regard to ownership, they did not make it possible to disentangle different levels of female ownership involvement. In particular, it was not possible to single out those firms in which women-owned the majority of the firm. Moreover, in determining the gender of management, the WBES only took into consideration those firms with a female top manager, therefore discounting the different levels of female involvement in managerial responsibilities (Presbitero et al., 2014). Nevertheless, the advantage of these indicators was that they provided empirical evidence about the role of women within the firms in a large sample of countries, therefore making it possible to benchmark the Caribbean countries.

Considering the proportion of firms with female participation in ownership, the Caribbean countries had relatively high ratios (above 40 percent) relative to the average for all countries in the survey (35.3 percent). Nonetheless, it is important to note the wide heterogeneity in the region, with countries like Suriname, Antigua and Barbuda, and Saint Lucia well below the regional average.

Taking into account the proportion of firms with a woman as the top manager, a female led more than 30 percent of firms in Belize, Guyana, and St. Vincent and the Grenadines, slightly over the WBES average (29 percent). But again there was a wide heterogeneity within the region, with Antigua and Barbuda, Barbados, Trinidad and Tobago, and Suriname, having less than 20 percent of firms with top female managers.

To benchmark female participation in ownership and top management in the Caribbean based on the large sample of countries included in the WBES, we estimated a gender frontier. The basic model presupposed that countries that had made the most progress in gender issues thanks to some structural characteristics would be on the gender frontier. In contrast, when a country having a similar level of structural endowments is less advanced in gender issues, it would lie below the gender frontier.

Using a tool similar to that outlined by Hussainy et al. (2011) in relation to financial development, we estimated the following regression equation:

$$GD_i = \beta X_i + \varepsilon_i \quad (1)$$

where GD_i is the measure of gender outcomes (ownership and top manager)[5] for country i, X_i is a matrix of structural conditions in the country, and is an error term that is assumed to have normal properties.

The structural factors included in the model specification were real gross domestic product (GDP) per capita, age dependency, educational attainment, health, and survival. Real GDP per capita was included to capture the potential benefits that economic prosperity might bring to women. The

[4] More information about the WBES is available at http://www.enterprisesurveys.org (accessed January 11, 2016).

[5] The two outcomes are calculated as indicated above and are the average values over 2002 and 2015 or for the period available for the different countries included in the WBES.

age dependency ratio captured the social pressures for women to stay at home to take care of children and older members of the family, as well as the pressure to enter the labor force. Improved health (i.e., life expectancy) and educational outcomes (i.e., enrollment ratios) should result in greater female participation in business.[6]

Equation 1 was used to predict the benchmark level of gender outcomes for each country in the WBES. Then, the gender gap was defined as the difference between the benchmark and the actual level. A positive (negative) gap value would therefore indicate that the country was under (over) performing relative to the rest of the countries in the survey.

The results from estimating Equation 1 are presented in Table 6.1, which provides the results for both gender indicators: (1) percent of firms with female participation in ownership; (2) percent of firms with a female top manager. In both cases, the model explains almost 10 percent of the variation in the two gender variables examined. The coefficient estimates were broadly in line with a priori expectations, with a higher enrollment ratio in secondary school being positively associated with both higher female ownership and participation in top management. Surprisingly, however, the coefficient on the GDP per capita suggested that wealthier countries had comparatively lower ratios of female ownership in business and female participation in management. This result does not mean that the absolute values of the ratios in these relatively more developed countries were lower, but it suggests that, relative to less developed counterparts, a higher rate of participation of females in business ownership and top management would be expected. In the regression on firms with a female top manager, the most important explanatory factor was the age dependency ratio.

TABLE 6.1. The Gender Frontier

	Percent of firms with female participation in ownership	Percent of firms with a female top manager
Ln (GDP per capita)	−0.146 (0.086)*	−0.174 (0.112)
Ln (dependency ratio)	−0.074 (0.331)	−0.817 (0.441)*
Ln (enrollment ratio in secondary education)	0.416 (0.187)**	0.384 (0.252)
Ln (life expectancy at birth)	0.120 (0.538)	−0.730 (0.733)
Constant	2.751 (2.950)	9.046 (4.022)**
R-squared	0.071	0.113
Root MSE	0.535	0.639
F-statistic	2.330 [0.059]	3.230 [0.015]
Observations	127	107

Source: WBES.
Notes: *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level. Standard errors are reported in parentheses.

Based on the regression results presented in Table 6.1, the predicted and actual values were used to estimate the gender gap in each country included in the database. The results (Table 6.2) suggest that the Caribbean was overperforming relative to other countries included in the survey, as the gender gap was negative for most Caribbean countries for which data were available. The gender gap indicator, which was derived from the share of firms with a female top manager, showed that nine out of the 10 countries considered presented a negative value. The measure of over- or underperformance was also similar considering the share of firms with female participation in ownership: six of the 10 countries had a negative value for the gender gap indicator.

The results presented above suggest that, based on their fundamental economic and social characteristics, Caribbean businesses are likely to have a relatively higher ratio of female participation in management and in ownership. In the following sections, we investigate the potential impact of female participation on firm productivity using data from the PROTEqIN database, which making it possible to more precisely measure the presence of women in firms.

[6] Data are from the World Development Indicators Database (see Footnote. 3). For each country, we considered the average values for 2002 and 2015.

TABLE 6.2. Estimated Gender Gap for Select Caribbean Countries

	Female participation in ownership	Firms with female top manager
Antigua and Barbuda	0.398	−0.134
The Bahamas	−0.677	−0.712
Barbados	−0.269	−0.389
Belize	0.050	0.644
Grenada	−0.511	−0.387
Jamaica	−0.134	−0.423
Saint Lucia	0.001	−0.401
St. Vincent and the Grenadines	−0.792	−0.790
Suriname	0.464	−0.021
Trinidad and Tobago	−0.471	−0.194

Source: Authors' calculations on WBES.

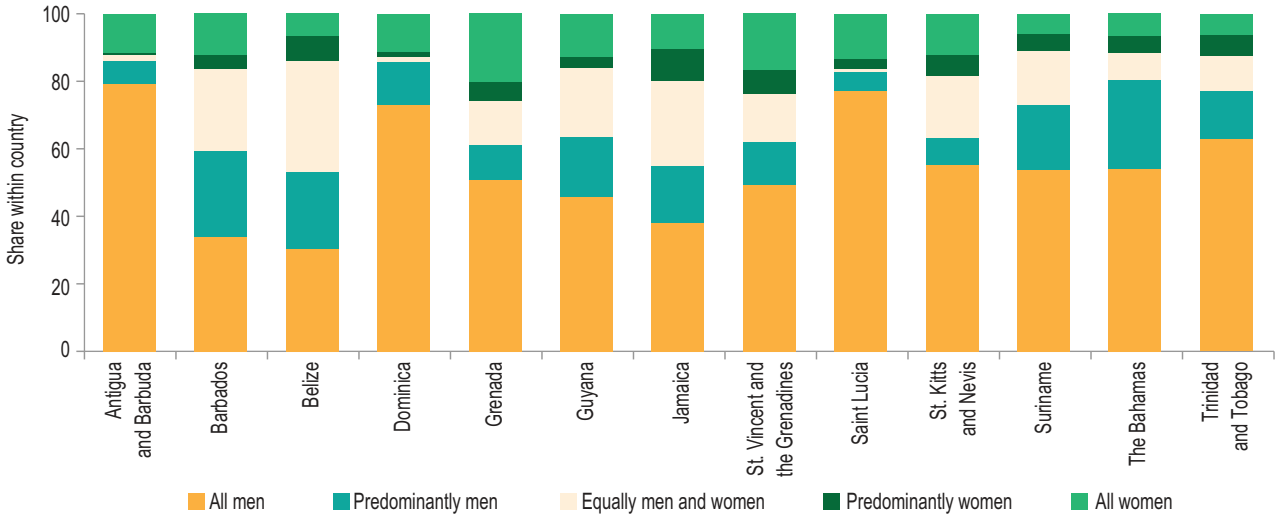
A Focus on the Gender Composition of Caribbean Firms

The following analysis was based on the micro data from the PROTEqIN survey completed in 13 Caribbean countries: Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, Saint Lucia, St. Kitts and Nevis, St. Vincent and the Grenadines, Suriname, and Trinidad and Tobago. The survey was a follow-up to the Latin American and Caribbean Enterprise Survey (LACES) implemented jointly by the Inter-American Development Bank, Compete Caribbean, and The World Bank. The PROTEqIN survey added new sections to WBES covering issues such as innovation and public program support. It targeted 1,680 respondents drawn from LACES.

PROTEqIN provides a wealth of information to precisely measure the presence of women in ownership and management of Caribbean firms and to assess their role in a firm's strategic decisions. The gender composition of a firm's management and ownership is classified in five categories: all men, predominantly men, equally men and women, predominantly women, and all women. Based on this information, it is possible to look at the relative incidence of women in ownership and management across countries and industries (Figures 6.1 and 6.2).

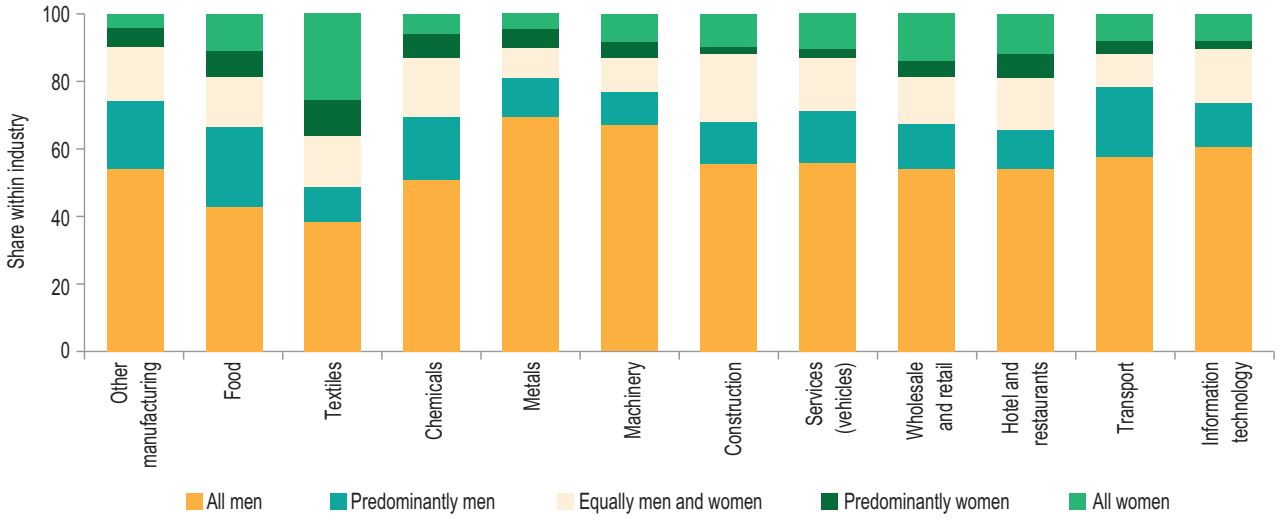
In several countries (Antigua and Barbuda, The Bahamas, Dominica, Saint Lucia, St. Kitts and Nevis, Suriname, and Trinidad and Tobago) more than 50 percent of the firms included in the survey were exclusively owned by men. Only three countries (Grenada, Jamaica, and St. Vincent and the Grenadines) had at least 20 percent of

FIGURE 6.1. Gender Composition of Firm Ownership in the Caribbean, by Country



Source: PROTEqIN.

FIGURE 6.2. Gender Composition of Firm Ownership in the Caribbean, by Industry



Source: PROTEqIN.

firms with female predominance among owners. Regarding sector specialization, as expected, the textile industry had the highest presence of female owners. The food, retail, restaurant, and transport industries also showed a relatively high share of firms owned by or predominantly by women.

Looking at women in management, the data showed a lower share of firms managed only by men, but in Antigua and Barbuda, Barbados, Dominica, Grenada, Jamaica, Saint Lucia, St. Kitts and Nevis, Suriname, and Trinidad and Tobago the share of firms predominantly managed by men was over 60 percent. The countries with at least 20 percent of companies predominantly managed by women were The Bahamas, Barbados, Belize, Grenada, Guyana, and St. Vincent and the Grenadines. In terms of sector specialization, again the textile, food, retail, and restaurant industries had predominantly female managers.

Table 6.3 confirms the limited overlap between the two categories: ownership and management.

TABLE 6.3. Gender Composition within Firm Ownership and Management (by number of firms)

		Ownership						
		All men	Predominantly men	Equally men and women	Predominantly women	All women	Total	% of total
Management	All men	297	41	46	22	37	443	22.7
	Predominantly men	411	153	111	46	81	802	41.2
	Equally men and women	170	52	75	20	27	344	17.7
	Predominantly women	109	47	37	15	22	230	11.8
	All women	73	2	12	2	40	129	6.6
	Total	1,060	295	281	105	207	1,948	100.0
	% of total	54.4	15.1	14.4	5.4	10.6	100.0	

Source: Authors based on PROTEqIN data.

TABLE 6.4. Gender Composition in Ownership and Management across Firm Characteristics (by percent of firms)

	Sole proprietorship		Ownership		Markets			Sector	
	No	Yes	Domestic	Foreign	Local	National	International	Manufacturing	Services
Women-led	0.064	0.158	0.105	0.068	0.099	0.098	0.103	0.093	0.102
Dominant owner	0.120	0.228	0.169	0.110	0.166	0.147	0.194	0.150	0.165
Dominant manager	0.161	0.225	0.192	0.148	0.193	0.166	0.239	0.152	0.201
Female owner	0.589	0.239	0.449	0.524	0.490	0.431	0.445	0.474	0.454
Female top manager	0.191	0.268	0.228	0.177	0.233	0.201	0.239	0.178	0.241
Observations	1,246	720	1,655	311	953	858	155	660	1,306

Source: Authors based on PROTEqIN data.

In particular, women were more likely to be part of the management structure, rather than being one of the owners. Ownership was fully in the hands of men in 54.4 percent of firms, while only 22.7 percent of firms were fully managed by men.

Table 6.4 presents five different indicators of gender composition in management and ownership of firms based on the PROTEqIN survey.

Women-led refers to firms with a woman as the major owner or shareholder and, among these firms, selects those in which the owner is in charge of major strategic and financial decisions (Presbitero et al., 2014). This dummy variable had restrictive conditions regarding the female presence in ownership and management so that we could be reasonably sure that the firm was actually led by a woman. By contrast, the standard variables used in the WBES did not identify firms with a woman as the main owner and decision maker unless the analysis was limited to sole proprietorships, where ownership and management responsibilities coincide. In other firms, this is not necessarily the case. In the sample, 54 percent of women who were top managers worked in firms where either all owners or the majority of owners were men. *Dominant owner* and *dominant manager* are dummy variables to identify firms with predominantly female ownership or management. *Female owner* and *female top manager* are dummy variables to distinguish firms with at least one woman among the owners or managers. These five gender variables measure different aspects (and intensity) of the gender composition of firms.

When looking at the structural features—sole proprietorship; domestic or foreign owned; local, national, or international market; and sector specialization (see Table 6.4)—along with the gender composition of firms, some key facts emerged and held across all indicators. First, women were more likely to play a greater role in management and ownership in sole proprietorships, which is consistent with the common finding that women-led businesses are smaller than men-led ones. Second, women tended to operate more domestic firms rather than foreign-owned ones. Third, there were no striking differences in export orientation or in specialization in the manufacturing or service sectors, even though there was a higher presence of women in managerial positions in services rather than in manufacturing.

Finally, the richness of the questionnaire made it possible to observe that women-led businesses perceived some barriers—access to financing (but not cost), crime, corruption, and the political environment—as more severe obstacles to their business activities than men-led firms (Figure 6.3).[7]

Gender Composition and Firm Characteristics

The component of women in ownership and management is likely to differ along different firm

[7] Similar findings held, with some minor differences, across the other four gender indicators. For brevity, results are not shown, but they are available on request from the authors.

FIGURE 6.3. Major Obstacles for Women-Led Businesses in the Caribbean

Source: Authors based on PROTEqIN data.

characteristics that can be associated with performance. This section shows the results of a study of whether women-owned and/or managed firms were different from other firms in terms of:

- **Size:** measured as the logarithm of the number of employees.
- **Age:** calculated by the logarithm of the number of years since the firm's inception.
- **Export:** a dummy variable with the value of 1 if the firm sold abroad and 0 otherwise.
- **Innovation:** a dummy variable with the value of 1 if the firm had recently introduced a new or significantly improved product or service and 0 otherwise.
- **Access to credit:** two dummy variables: (1) **Demand for bank credit**, with a value of 1 if the firm had asked a bank for credit and 0 otherwise; (2) **Financing as an obstacle**, with a value of 1 if the firm perceived access to credit as a major obstacle and 0 otherwise.
- **Technical assistance:** a dummy variable with a value of 1 if the firm had benefited from any technical assistance programs and 0 otherwise.

We ran a set of simple regressions, including, alternatively, each of the five gender indicators presented in the previous section, and country and sector fixed effects. As a second step, we augmented each model with a set of standard firm-level controls to better identify the gender gap and avoid attributing it to possible omitted variables. Depending on the nature of the dependent variable, the models were estimated as Linear or Probit.

Gender and firm size. Consistent with a large body of literature (Aterido et al., 2013; Bardasi, Sabarwal, and Terrell, 2011; Bruhn, 2009; Sabarwal and Terrell, 2008), Table 6.5 shows that firms with some female participation defined according to the five alternative gender indicators previously introduced, are significantly smaller than other firms. This finding was also robust when including firm-level variables, even though the point estimates were generally halved.

Gender and firm age. The results were less clear-cut for gender and firm age (Table 6.6). When women were predominant in management (*dominant manager*), the coefficient was statistically significant, as was the case for women-led businesses, but the latter correlation did not hold once firm-level controls were included in the regression model, suggesting that the correlation was driven by an omitted variable (i.e., size).

Gender and export propensity. Consistent with what is shown in Table 6.4, the results for gender and exporting did not support the hypothesis that the gender composition of a firm is a significant predictor of the likelihood of being present in international markets. This was true even without controlling for other firm characteristics (Table 6.7).

Gender and innovation. We considered the possibility of a gender gap in a firm's propensity to innovate, assuming women may be more risk averse (Croson and Gneezy, 2009; Dohmen et al., 2011) and, therefore, less prone to innovate (Chen et al., 2015). Table 6.8 shows that the empirical evidence did not support this assumption.[8]

[8] Results (which, for brevity, are not shown, but are available on request from the authors) were confirmed when we measured the propensity to innovate with a dummy for firms that had a research and development department.

TABLE 6.5. Gender Composition and Firm Size

Dependent variable: size	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Women-led	−0.401***	−0.193**								
	(0.085)	(0.081)								
Dominant owner			−0.328***	−0.194***						
			(0.069)	(0.063)						
Dominant manager					−0.262***	−0.138**				
					(0.069)	(0.060)				
Female owner							0.067	−0.173***		
							(0.054)	(0.052)		
Female top manager									−0.416***	−0.278***
									(0.062)	(0.057)
Age		0.479***		0.481***		0.475***		0.479***		0.470***
		(0.038)		(0.038)		(0.038)		(0.038)		(0.038)
Export (0/1)		0.190***		0.198***		0.191***		0.184***		0.188***
		(0.066)		(0.066)		(0.066)		(0.066)		(0.066)
Innovation (0/1)		0.178***		0.171***		0.175***		0.182***		0.165**
		(0.065)		(0.065)		(0.065)		(0.065)		(0.065)
Foreign ownership (0/1)		0.426***		0.421***		0.423***		0.425***		0.410***
		(0.071)		(0.071)		(0.071)		(0.071)		(0.070)
Sole proprietorship (0/1)		−0.516***		−0.514***		−0.527***		−0.593***		−0.523***
		(0.049)		(0.049)		(0.049)		(0.052)		(0.048)
Financing as an obstacle (0/1)		−0.152***		−0.154***		−0.163***		−0.160***		−0.159***
		(0.052)		(0.052)		(0.052)		(0.052)		(0.052)
Technical assistance (0/1)		0.089		0.086		0.085		0.084		0.088
		(0.066)		(0.066)		(0.066)		(0.066)		(0.065)
Observations	1,821	1,821	1,821	1,821	1,821	1,821	1,821	1,821	1,821	1,821
R-squared	0.112	0.296	0.112	0.297	0.109	0.296	0.102	0.298	0.123	0.303
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Source: Authors based on PROTEqIN data.
Notes: Linear regression with robust standard errors. *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

TABLE 6.6. Gender Composition and Firm Age

Dependent variable: age	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Women-led	−0.090*	−0.009								
	(0.052)	(0.050)								
Dominant owner			−0.026	0.038						
			(0.042)	(0.040)						
Dominant manager					−0.125***	−0.079**				
					(0.040)	(0.038)				
Female owner							0.025	0.008		
							(0.032)	(0.032)		
Female top manager									−0.123***	−0.045
									(0.036)	(0.035)
Size		0.184***		0.185***		0.182***		0.184***		0.182***
		(0.015)		(0.015)		(0.015)		(0.015)		(0.015)
Export (0/1)		0.066*		0.064*		0.068*		0.066*		0.067*
		(0.038)		(0.038)		(0.038)		(0.038)		(0.038)
Innovation (0/1)		0.073*		0.074*		0.073*		0.073*		0.072*
		(0.039)		(0.039)		(0.039)		(0.039)		(0.039)
Foreign ownership (0/1)		−0.071*		−0.071*		−0.073*		−0.071*		−0.073*
		(0.042)		(0.042)		(0.042)		(0.042)		(0.042)
Sole proprietorship (0/1)		−0.019		−0.023		−0.016		−0.016		−0.019
		(0.032)		(0.032)		(0.031)		(0.034)		(0.031)
Financing as an obstacle (0/1)		−0.059*		−0.060*		−0.060*		−0.059*		−0.059*
		(0.033)		(0.033)		(0.033)		(0.033)		(0.033)
Technical assistance (0/1)		0.027		0.029		0.023		0.028		0.027
		(0.036)		(0.036)		(0.036)		(0.036)		(0.036)
Observations	1,821	1,821	1,821	1,821	1,821	1,821	1,821	1,821	1,821	1,821
R-squared	0.083	0.186	0.082	0.186	0.087	0.188	0.082	0.186	0.087	0.186
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Source: Authors based on PROTEqIN data.
Notes: Linear regression with robust standard errors. *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

Gender and access to credit. Tables 6.9 and 6.10 confirm a gender gap in access to financing when considering the gender indicator *women-led*, supporting what was found by Presbitero et al. (2014) on a smaller sample of Caribbean countries. We found robust evidence that women-led firms were less likely to ask for credit from a bank but also to consider access to financing as a severe obstacle to business activities than other firms, even controlling for firm characteristics. Demand for credit was also confirmed for female-owner firms (Table 6.9).

Gender and technical assistance. Finally, we considered the possibility that firms with a significant

TABLE 6.7. Gender Composition and Firm Propensity to Export

Dependent variable: export	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Women-led	−0.017	0.123								
	(0.125)	(0.129)								
Dominant owner			0.104	0.237**						
			(0.094)	(0.096)						
Dominant manager					0.039	0.140				
					(0.092)	(0.097)				
Female owner							0.077	−0.050		
							(0.073)	(0.080)		
Female top manager									−0.099	0.004
									(0.089)	(0.092)
Size		0.116***		0.120***		0.116***		0.111***		0.114***
		(0.036)		(0.036)		(0.036)		(0.036)		(0.036)
Age		0.122**		0.121**		0.125**		0.122**		0.122**
		(0.058)		(0.058)		(0.058)		(0.058)		(0.058)
Innovation (0/1)		0.436***		0.441***		0.437***		0.441***		0.438***
		(0.089)		(0.089)		(0.089)		(0.089)		(0.089)
Foreign ownership (0/1)		0.257***		0.266***		0.261***		0.256***		0.257***
		(0.094)		(0.094)		(0.094)		(0.094)		(0.094)
Sole proprietorship (0/1)		−0.303***		−0.310***		−0.301***		−0.311***		−0.293***
		(0.085)		(0.086)		(0.085)		(0.089)		(0.084)
Financing as an obstacle (0/1)		−0.037		−0.039		−0.032		−0.033		−0.033
		(0.088)		(0.088)		(0.088)		(0.088)		(0.088)
Technical assistance (0/1)		0.129		0.133		0.137		0.126		0.129
		(0.096)		(0.096)		(0.096)		(0.096)		(0.096)
Observations	1,821	1,821	1,821	1,821	1,821	1,821	1,821	1,821	1,821	1,821
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Source: Authors based on PROTEqIN data.
Notes: Probit regression with robust standard errors. *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

component of women in management or ownership might have had a disadvantage in accessing technical assistance programs. Results did not show any strong pattern, other than for firms with a predominant share of women in management. These firms were less likely to take advantage of technical assistance programs than comparable firms, even when we took into account differences along observable firm characteristics (Table 6.11).

Is There a Gender Gap in Firm Productivity?

The empirical analysis presented so far shows that the gender composition of a firm is significantly associated with some key firm characteristics—notably size and access to financing—that are likely to affect firm performance (Van Biesebroeck, 2005a; Grazzi, Pietrobelli, and Szirmai, 2015; Beck and

TABLE 6.8. Gender Composition and Firm Propensity to Innovate

Dependent variable: innovation	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Women-led	0.056	0.126								
	(0.127)	(0.130)								
Dominant owner			−0.089	−0.066						
			(0.102)	(0.105)						
Dominant manager					−0.007	0.029				
					(0.094)	(0.096)				
Female owner							0.118	0.145*		
							(0.075)	(0.081)		
Female top manager									−0.178*	−0.127
									(0.092)	(0.094)
Size		0.096***		0.093**		0.095***		0.100***		0.090**
		(0.037)		(0.037)		(0.037)		(0.037)		(0.037)
Age		0.114*		0.113*		0.114*		0.116**		0.110*
		(0.059)		(0.059)		(0.059)		(0.059)		(0.059)
Export (0/1)		0.414***		0.419***		0.415***		0.418***		0.417***
		(0.089)		(0.090)		(0.090)		(0.090)		(0.089)
Foreign ownership (0/1)		0.018		0.017		0.020		0.022		0.011
		(0.106)		(0.106)		(0.106)		(0.106)		(0.107)
Sole proprietorship (0/1)		0.030		0.044		0.039		0.091		0.038
		(0.083)		(0.082)		(0.082)		(0.087)		(0.082)
Financing as an obstacle (0/1)		−0.049		−0.039		−0.042		−0.043		−0.042
		(0.087)		(0.087)		(0.087)		(0.087)		(0.087)
Technical assistance (0/1)		0.048		0.045		0.048		0.052		0.045
		(0.097)		(0.097)		(0.098)		(0.097)		(0.097)
Observations	1,821	1,821	1,821	1,821	1,821	1,821	1,821	1,821	1,821	1,821
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Source: Authors based on PROTEqIN data.
Notes: Probit regression with robust standard errors. *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

Demirgüç-Kunt, 2006). To investigate the presence of a gender gap in firm performance, we estimated a simple model for the drivers of firm productivity, augmented with the different proposed measures of gender composition within the firm. We measured firm productivity by: (1) value added per worker, (2) sales per worker, and (3) total factor productivity (TFP), measured as the residual of the production function. In particular, following Saliola and Seker (2011), who calculated TFP in 80 developing countries using micro data from the WBES, we estimated a log-linearized Cobb-Douglas function with the value of sales (question K1B in the PROTEqIN survey) as output, and total labor costs (question K2B), the replacement cost of machinery and equipment (question K7), and total intermediate costs (K1B) as inputs.

For each of the five gender variables, we estimated the model controlling only for sector and

TABLE 6.9. Gender Composition and Firm Demand for Bank Credit

Dependent variable: credit application	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Women-led	−0.293***	−0.267**								
	(0.107)	(0.108)								
Dominant owner			−0.259***	−0.237***						
			(0.085)	(0.086)						
Dominant manager					−0.144*	−0.124				
					(0.080)	(0.081)				
Female owner							−0.104	−0.137**		
							(0.064)	(0.068)		
Female top manager									−0.066	−0.039
		0.065**		0.064**		0.067**		0.064**		0.068**
Size		(0.031)		(0.031)		(0.031)		(0.031)		(0.031)
		0.022		0.026		0.019		0.024		0.022
Age		(0.050)		(0.050)		(0.050)		(0.050)		(0.050)
		−0.087		−0.078		−0.085		−0.092		−0.089
Export (0/1)		(0.081)		(0.081)		(0.081)		(0.081)		(0.081)
		0.030		0.021		0.025		0.031		0.024
Innovation (0/1)		(0.083)		(0.083)		(0.083)		(0.083)		(0.083)
		−0.079		−0.085		−0.082		−0.078		−0.080
Foreign ownership (0/1)		(0.088)		(0.088)		(0.087)		(0.088)		(0.088)
		−0.030		−0.030		−0.045		−0.098		−0.049
Sole proprietorship (0/1)		(0.069)		(0.068)		(0.068)		(0.072)		(0.068)
		0.020		0.017		0.018		0.018		0.023
Technical assistance (0/1)		(0.082)		(0.082)		(0.082)		(0.082)		(0.082)
									(0.076)	(0.077)
Observations	1,821	1,821	1,821	1,821	1,821	1,821	1,821	1,821	1,821	1,821
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Source: Authors based on PROTEqIN data.
Notes: Probit regression with robust standard errors. *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

country fixed effects. Then, we added a standard set of control variables to examine whether the gender gap in firm productivity (if found) could be explained by firm characteristics. In particular, following what was done in the previous section, we included firm size and age measured by the logarithm of the number of employees and the number of years since inception, respectively. We also included a set of dummy variables to identify firms that (1) exported some of their production, (2) introduced a new or significantly improved product or service as a proxy for firm propensity to innovate, (3) were foreign owned, (4) were sole proprietorships, (5) considered access to financing a major or very severe obstacle to business activities, and (6) benefited from any technical assistance program.

TABLE 6.10. Gender Composition and Financing as an Obstacle to Firm Activity

Dependent variable: financing as an obstacle	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Women-led	0.298***	0.266**								
	(0.107)	(0.109)								
Dominant owner			0.154*	0.128						
			(0.088)	(0.090)						
Dominant manager					−0.042	−0.074				
					(0.085)	(0.087)				
Female owner							−0.008	0.010		
							(0.069)	(0.075)		
Female top manager									0.038	−0.013
									(0.080)	(0.082)
Size		−0.093***		−0.095***		−0.100***		−0.098***		−0.099***
		(0.033)		(0.033)		(0.034)		(0.034)		(0.034)
Age		−0.092*		−0.093*		−0.094*		−0.091*		−0.092*
		(0.054)		(0.054)		(0.054)		(0.054)		(0.054)
Export (0/1)		−0.056		−0.060		−0.048		−0.051		−0.050
		(0.090)		(0.090)		(0.089)		(0.089)		(0.089)
Innovation (0/1)		−0.058		−0.051		−0.053		−0.054		−0.054
		(0.091)		(0.091)		(0.091)		(0.091)		(0.091)
Foreign ownership (0/1)		−0.004		0.001		−0.005		−0.002		−0.002
		(0.097)		(0.097)		(0.097)		(0.097)		(0.097)
Sole proprietorship (0/1)		−0.030		−0.016		−0.002		−0.001		−0.004
		(0.074)		(0.074)		(0.073)		(0.079)		(0.073)
Technical assistance (0/1)		0.067		0.066		0.059		0.063		0.063
		(0.088)		(0.088)		(0.088)		(0.088)		(0.088)
Observations	1,821	1,821	1,821	1,821	1,821	1,821	1,821	1,821	1,821	1,821
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Source: Authors based on PROTEqIN data.
Notes: Probit regression with robust standard errors. *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

Tables 6.12–6.14 consistently show that there was a gender gap in productivity irrespective of the measure of gender composition, with the only exception being the dummy *female owner*, which identifies firms with at least one woman among the owners, and *women-led business*, which was not significant when firm performance was measured by TFP, even though the coefficient was negative.

However, in line with evidence for advanced economies (Wolfers, 2006) and Latin America (Abrahams et al, 2016; Flabbi et al., 2014), once we controlled for firm characteristics other than industries and countries, we found that the productivity gap vanished for *women-led* businesses and for firms that were predominantly owned by women (*dominant owner*). The

TABLE 6.11. Gender Composition and Technical Assistance

Dependent variable: technical assistance	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Women-led	−0.087	−0.110								
	(0.126)	(0.128)								
Dominant owner			−0.119	−0.139						
			(0.100)	(0.102)						
Dominant manager					−0.210**	−0.213**				
					(0.097)	(0.098)				
Female owner							−0.146*	−0.122		
							(0.075)	(0.079)		
Female top manager									−0.075	−0.060
									(0.088)	(0.089)
Size		0.058		0.056		0.056		0.056		0.057
		(0.038)		(0.038)		(0.038)		(0.038)		(0.038)
Age		0.045		0.046		0.038		0.045		0.043
		(0.058)		(0.058)		(0.058)		(0.057)		(0.057)
Export (0/1)		0.147		0.152		0.152		0.142		0.146
		(0.093)		(0.093)		(0.093)		(0.093)		(0.093)
Innovation (0/1)		0.063		0.059		0.063		0.068		0.060
		(0.095)		(0.095)		(0.095)		(0.095)		(0.095)
Foreign ownership (0/1)		−0.150		−0.152		−0.155		−0.149		−0.153
		(0.106)		(0.106)		(0.106)		(0.106)		(0.106)
Sole proprietorship (0/1)		0.132		0.136*		0.131		0.082		0.124
		(0.081)		(0.081)		(0.080)		(0.084)		(0.080)
Financing as an obstacle (0/1)		0.077		0.078		0.070		0.073		0.073
		(0.083)		(0.083)		(0.083)		(0.083)		(0.083)
Observations	1,821	1,821	1,821	1,821	1,821	1,821	1,821	1,821	1,821	1,821
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Source: Authors based on PROTEqIN data.
Notes: Probit regression with robust standard errors. *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

performance gap survived only when considering the gender composition of firm management (*dominant manager* and *female top manager*).

The results for the other firm-level variables were in line with the evidence on the drivers of firm performance in the literature, supporting the fact that the overall model was well specified. In particular, firms that are larger, older, and export oriented are more productive, and access to financing is strongly associated with firm performance (Van Biesebroeck, 2005b).

Blinder–Oaxaca Decomposition

We carried out the counterfactual decomposition of the difference in the average performance across

TABLE 6.12. Gender Composition and Firm Productivity (*value added per worker*)

Dependent variable: value added per worker	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Women-led	−0.152**	−0.072								
	(0.075)	(0.074)								
Dominant owner			−0.123**	−0.073						
			(0.061)	(0.060)						
Dominant manager					−0.163***	−0.124**				
					(0.057)	(0.057)				
Female owner							0.027	−0.018		
							(0.049)	(0.053)		
Female top manager									−0.241***	−0.186***
									(0.058)	(0.059)
Size		0.077***		0.076***		0.075***		0.077***		0.069***
		(0.024)		(0.025)		(0.024)		(0.025)		(0.025)
Age		0.087**		0.088**		0.083**		0.087**		0.083**
		(0.039)		(0.039)		(0.039)		(0.039)		(0.038)
Export (0/1)		0.132**		0.135**		0.134**		0.130**		0.132**
		(0.062)		(0.062)		(0.062)		(0.062)		(0.062)
Innovation (0/1)		0.037		0.035		0.037		0.037		0.031
		(0.059)		(0.059)		(0.058)		(0.059)		(0.058)
Foreign ownership (0/1)		0.058		0.057		0.055		0.058		0.050
		(0.073)		(0.073)		(0.073)		(0.073)		(0.073)
Sole proprietorship (0/1)		−0.083*		−0.083*		−0.085*		−0.096*		−0.087*
		(0.051)		(0.050)		(0.051)		(0.056)		(0.050)
Financing as an obstacle (0/1)		−0.159***		−0.160***		−0.165***		−0.162***		−0.163***
		(0.051)		(0.051)		(0.051)		(0.051)		(0.051)
Technical assistance (0/1)		0.039		0.038		0.034		0.039		0.038
		(0.061)		(0.060)		(0.061)		(0.060)		(0.060)
Observations	1,821	1,821	1,821	1,821	1,821	1,821	1,821	1,821	1,821	1,821
R-squared	0.664	0.676	0.664	0.676	0.665	0.676	0.664	0.676	0.667	0.677
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Source: Authors based on PROTEqIN data.
Notes: Linear regression with robust standard errors. *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

women-managed firms and other firms using the standard Blinder (1973) and Oaxaca (1973) approach. This technique is widely used in the literature on wage gaps across gender or race to decompose the gap in firm performance into two components: (1) the explained part due to differences in characteristics across groups, and (2) the residual or the unexplained part, which can be interpreted as a measure of

TABLE 6.13. Gender Composition and Firm Productivity (*sales per worker*)

Dependent variable: sales per worker	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Women-led	−0.151**	−0.064								
	(0.070)	(0.070)								
Dominant owner			−0.131**	−0.076						
			(0.058)	(0.057)						
Dominant manager					−0.154***	−0.112**				
					(0.054)	(0.053)				
Female owner							0.033	−0.018		
							(0.047)	(0.050)		
Female top manager									−0.222***	−0.162***
									(0.054)	(0.055)
Size		0.070***		0.069***		0.069***		0.071***		0.064***
		(0.023)		(0.023)		(0.023)		(0.023)		(0.024)
Age		0.096***		0.098***		0.093**		0.097***		0.093**
		(0.037)		(0.037)		(0.037)		(0.037)		(0.037)
Export (0/1)		0.148**		0.151**		0.150**		0.146**		0.148**
		(0.060)		(0.060)		(0.060)		(0.060)		(0.059)
Innovation (0/1)		0.015		0.013		0.015		0.015		0.010
		(0.057)		(0.057)		(0.056)		(0.056)		(0.056)
Foreign ownership (0/1)		0.114*		0.112*		0.112*		0.114*		0.107
		(0.067)		(0.067)		(0.067)		(0.067)		(0.067)
Sole proprietorship (0/1)		−0.097**		−0.096**		−0.099**		−0.109**		−0.101**
		(0.048)		(0.047)		(0.047)		(0.052)		(0.047)
Financing as an obstacle (0/1)		−0.181***		−0.181***		−0.186***		−0.183***		−0.184***
		(0.049)		(0.049)		(0.049)		(0.049)		(0.049)
Technical assistance (0/1)		0.075		0.073		0.070		0.075		0.074
		(0.058)		(0.058)		(0.059)		(0.058)		(0.058)
Observations	1,821	1,821	1,821	1,821	1,821	1,821	1,821	1,821	1,821	1,821
R-squared	0.693	0.706	0.693	0.706	0.693	0.707	0.692	0.706	0.695	0.708
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Source: Authors based on PROTEqIN data.
Notes: Linear regression with robust standard errors. *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

discrimination, even though it could include the effect of other unobserved heterogeneity (omitted variables that can differ across the two groups of firms and can contribute to predicting performance).

The results of the two-fold decomposition for the two gender variables showed a gender gap after controlling for firm characteristics, as shown in Table 6.15. Measuring performance by

TABLE 6.14. Gender Composition and Firm Productivity (total factor productivity)

Dependent variable: TFP	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Women-led	−0.022	−0.010								
	(0.023)	(0.023)								
Dominant owner			−0.032*	−0.024						
			(0.019)	(0.019)						
Dominant manager					−0.041**	−0.036**				
					(0.017)	(0.018)				
Female owner							0.012	0.008		
							(0.016)	(0.016)		
Female top manager									−0.060***	−0.053***
									(0.017)	(0.017)
Size		0.012		0.012		0.012		0.013		0.010
		(0.008)		(0.008)		(0.008)		(0.008)		(0.008)
Age		0.001		0.001		−0.000		0.001		−0.000
		(0.012)		(0.012)		(0.012)		(0.012)		(0.012)
Export (0/1)		−0.002		−0.001		−0.001		−0.002		−0.002
		(0.019)		(0.019)		(0.019)		(0.019)		(0.018)
Innovation (0/1)		0.003		0.002		0.003		0.002		0.001
		(0.022)		(0.022)		(0.022)		(0.022)		(0.022)
Foreign ownership (0/1)		0.031		0.030		0.030		0.031		0.029
		(0.023)		(0.023)		(0.023)		(0.023)		(0.023)
Sole proprietorship (0/1)		−0.007		−0.006		−0.006		−0.005		−0.007
		(0.016)		(0.016)		(0.016)		(0.017)		(0.016)
Financing as an obstacle (0/1)		−0.032*		−0.032*		−0.033*		−0.033*		−0.033*
		(0.017)		(0.017)		(0.017)		(0.017)		(0.017)
Technical assistance (0/1)		0.005		0.004		0.003		0.005		0.004
		(0.020)		(0.020)		(0.020)		(0.020)		(0.020)
Observations	1,770	1,770	1,770	1,770	1,770	1,770	1,770	1,770	1,770	1,770
R-squared	0.001	0.009	0.002	0.010	0.004	0.011	0.001	0.009	0.007	0.014
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Source: Authors based on PROTEqIN data.
Notes: Linear regression with robust standard errors. *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

sales or value added per worker provided almost an identical picture. The performance of *dominant manager* firms was lower than that of other firms, and two-thirds of this gap was due to unobserved factors; the explained part of the gap was not statistically different from zero.

Dissimilarly, in firms with a *female top manager*, the explained part of the gap accounted for almost half of the total gap and both components were statistically greater than zero. In particular, it is worth noting that size, age, and, to a lesser extent, access to financing were

TABLE 6.15. Gender Composition and Firm Productivity: Blinder–Oaxaca Decomposition

	$E[Y_{FEMALE=0}]$ (1)	$E[Y_{FEMALE=1}]$ (2)	Difference (3)	Explained (4)	Unexplained (5)	% Unexplained (6)	Observations
Value added per worker							
Dominant manager	11.640	11.462	0.178	0.057	0.120	67.8	1,821
			(0.080)	(0.503)	(0.033)		
Female top manager	11.686	11.325	0.360	0.176	0.184	51.2	1,821
			(0.000)	(0.030)	(0.001)		
Sales per worker							
Dominant manager	12.354	12.189	0.165	0.058	0.107	65.0	1,821
			(0.106)	(0.510)	(0.042)		
Female top manager	12.391	12.080	0.311	0.150	0.161	51.8	1,821
			(0.001)	(0.068)	(0.003)		
TFP							
Dominant manager	0.011	−0.028	0.039	0.003	0.036	93.3	1,770
			(0.021)	(0.543)	(0.038)		
Female top manager	0.015	−0.040	0.055	0.002	0.053	96.3	1,770
			(0.001)	(0.689)	(0.002)		

Source: Authors based on PROTEqIN data.
Notes: The table reports the two-fold Blinder–Oaxaca decomposition of the gender gap for alternative measures of firm productivity and for two measures of gender composition in the firm management (by row). Results are obtained using the Stata routine Oaxaca (Jann, 2008). Column 5 (Explained) reports the part of the difference in means (Column 4) that was due to group differences in the predictors (the 'endowments effect'), while Column 6 reports the Unexplained part. Numbers in parentheses for Columns 4–6 report the p-values of the test when the expected values and the difference were equal to zero. See Jann (2008) for additional details.

the three observable variables that significantly contributed to explaining part of the difference in firm productivity across the gender composition of management. This was consistent with the previous evidence about the existence of a gender gap in firm size and age.

Finally, considering TFP, almost all of the difference between firms with a dominant manager or a female top manager and the others was unexplained, but this result was likely due to the fact that the TFP was estimated as a residual from an auxiliary regression.

Conclusions

Female participation in management and ownership of Caribbean firms is relatively high compared to international standards. This study found that women-led businesses differed from other Caribbean firms in several characteristics. In particular, a larger presence of women in management and ownership of a firm was often associated with smaller size, younger age, domestic ownership, and limited access to financing. Some of these stylized facts differed depending on the measure of gender composition within the firm, supporting the finding that having a different gender balance in ownership or in management was associated with different firm characteristics.

The main analysis focused on a gender gap in firm performance and showed that firms with female management (*dominant manager* and *female top manager*) were in fact less productive than comparable firms, even after controlling for country and sector fixed effects and for a large set of firm-level variables that drive productivity. This result, however, was not valid for *women-led* businesses and for firms that were predominantly

owned by women (*dominant owner*), which were as productive as comparable firms.

The evidence discussed in this chapter provides some novel insights on the role of gender in firm performance in the Caribbean. The results can help design effective policy interventions aimed at narrowing the gender gap in firm productivity. In particular, we found that differences in firm size, age, and access to financing across gender explained a significant part of the productivity gap of firms with women among the key managers. Thus, policies aimed at promoting firm growth and access to financing for businesses managed by women are likely to be the most effective in narrowing the gender productivity gap.

References

Abrahams, S., L. Flabbi, and C. Piras. 2016. *Female Corporate Leadership in Latin America and the Caribbean Region: Representation and Firm-Level Outcomes*. Washington, DC: Inter-American Development Bank.

Aterido, R., T. Beck, and L. Iacovone. 2013. "Access to Finance in Sub-Saharan Africa: Is there a Gender Gap." *World Development* 47:102–20.

Bailey, B. 2003. "The Search for Gender Equity and Empowerment of Caribbean Women: The Role of Education." In G. Tang Nain and B. Bailey, *Gender Equity in the Caribbean: Reality or Illusion*, pp.108–45. Kingston: Ian Randle Publishers.

Bardasi, E., S. Sabarwal, and K. Terrell. 2011. "How Do Female Entrepreneurs Perform? Evidence from Three Developing Regions." *Small Business Economics* 37(4):417–41.

Beck, T., and A. Demirgüç-Kunt. 2006. "Small and Medium-Sized Enterprises: Access to Finance as a Growth Constraint." *Journal of Banking and Finance* 30(11):2931–43.

Blinder, A. 1973. "Wage Discrimination: Reduced form and Structural Estimates." *Journal of Human Resources* 8:436–55.

Bruhn, M. 2009. "Female-Owned Firms in Latin America: Characteristics, Performance, and Obstacles to Growth." Policy Research Working Paper Series. Washington, DC: The World Bank.

Chen, J., W. Leung, and K. Evans. 2015. "Board Gender Diversity, Innovation and Firm Performance." Unpublished manuscript. Cardiff: Cardiff University.

Croson, R., and U. Gneezy. 2009. "Gender Differences in Preferences." *Journal of Economic Literature* 47:448–74.

Dohmen, T., A. Falk, D. Huffman, U. Sunde, J. Schupp, and G. Wagner. 2011. "Individual Risk Attitudes: Measurement, Determinants, and Behavioral Consequences." *Journal of the European Economic Association* 9(3):522–50.

Ferdinand, C. 2001. "Jobs, Gender and Small Enterprises in the Caribbean: Lessons from Barbados, Suriname, and Trinidad and Tobago." SEED Working Paper. Geneva: International Labour Organisation.

Flabbi, L., M. Macis, A. Moro, and F. Schivardi. 2014. "Do Female Executives Make a Difference? The Impact of Female Leadership on Gender Gaps and Firm Performance." CEPR Discussion Paper Series. London, UK: Centre for Economic Policy Research.

Gagliarducci, S., and D. Paserman. 2015. "The Effect of Female Leadership on Establishment and Employee Outcomes: Evidence from Linked Employer-Employee Data." *Research in Labor Economics* 41:341–72.

Grazzi, M., C. Pietrobelli, and A. Szirmai. 2015. "The Performance of Firms in Latin America and the Caribbean: Microeconomic Factors and the Role of Innovation." Working Paper Series. Maastricht: United Nations University-Maastricht Economic and Social Research Institute on Innovation and Technology (MERIT).

Hussainy, A. (ed.), A. Coppola, E. Feyen, A. Ize, K. Kibbuka, and H. Ren. 2011. *Fin Stats 2011: A Ready-to-Use Tool to Benchmark Financial Sectors Across Countries and Over Time*. Washington, DC: The World Bank.

ILO. 2015. "Women in Business and Management. Gaining Momentum." Global Report. Geneva: International Labour Organisation.

Jann, B. 2008. "A Stata Implementation of the Blinder–Oaxaca Decomposition." *The Stata Journal* 8(4):453–79.

Kanter, R. 1977. "Some Effects of Proportions on Group Life: Skewed Sex Ratios and Responses to Token Women." *American Journal of Sociology* 82(5):965–90.

Klapper, L., and S. Parker. 2011. "Gender and the Business Environment for New Firm Creation." *The World Bank Research Observer* 26(2):237–57.

Marques, H. 2015. "Does the Gender of Top Managers and Owners Matter for Firm Exports?" *Feminist Economics* 21(4):89–117.

Oaxaca, R. 1973. "Male-Female Wage Differentials in Urban Labor Markets." *International Economic Review* 14:693–709.

Orser, B., M. Spence, A. Riding, and C. Carrington. 2010. "Gender and Export Propensity." *Entrepreneurship Theory and Practice* 34(5):933–57.

Presbitero, A., R. Rabellotti, and C. Piras. 2014. "Barking up the Wrong Tree? Measuring Gender Gaps in Firm's Access to Finance." *Journal of Development Studies* 50(10):1430–44.

Sabarwal, S., and K. Terrell. 2008. "Does Gender Matter for Firm Performance? Evidence from Eastern Europe and Central Asia." Policy Research Working Paper Series. Washington, DC: The World Bank.

Saliola, F., and M. Seker. 2011. "Total Factor Productivity across the Developing World." Brief. Washington, DC: The World Bank.

Smith, N., V. Smith, and M. Verner. 2006. "Do Women in Top Management Affect Firm Performance? A Panel Study of 2,500 Danish Firms." *International Journal of Productivity and Performance Management* 55(7):569–93.

Van Biesebroeck, J. 2005a. "Firm Size Matters: Growth and Productivity Growth in African Manufacturing." *Economic Development and Cultural Change* 53(3):545–83.

———. 2005b. "Exporting Raises Productivity in Sub-Saharan African Manufacturing Firms." *Journal of International Economics* 67(2):373–91.

Wolfers, J. 2006. "Diagnosing Discrimination: Stock Returns and CEO Gender." *Journal of the European Economic Association* 4(2–3):531–41.

7

Firm Response to Erratic Power Supply: New Evidence from Caribbean Firms

Manuel Barron

A fast-growing body of literature assesses how rural electrification molds household behavior. Studies have found effects of access to electrification on a wealth of socioeconomic variables like employment (Dinkelman, 2011), indoor air quality (Barron and Torero, 2015a), energy use, time allocation, and income (Barron and Torero, 2015b; Bensch, Kluve, and Peters, 2010; Khandker, Barnes, and Samad, 2012, 2013; Chakravorty, Pelli, and Marchand, 2013), housing value and human development (Lipscomb, Mobarak, and Barham, 2013). However, there is still scarce evidence on the role that access to electricity plays on firm performance and industry development, two key elements of economic growth. A notable exception is the study by Rud (2012), who showed that electrification boosted the development of the manufacturing sector in India. Ryan (2013) went a step further and showed that quality of provision matters. He found that firms increase supply in response to a more integrated grid, leading to sizeable increases in market surplus. Conversely, other studies have shown that intermittent, unreliable electricity, and unexpected outages or surges can hurt firm performance. Power outages cost businesses in terms of lost sales (e.g., Allcott, Collard-Wexler, and O'Connell, 2015; Beenstock, Goldin, and Haitovsky, 1997; Adenikinju, 2005) as well as equipment damage, as documented by Foster and Steinbuks (2009). Alam (2013) provided evidence of heterogeneity in the effect of outages, showing that power outages lower profits and output of some electricity-intensive industries in India, but not across the board.

Several studies have found that firms strategically reallocate resources to cope with unreliable electricity supply; most saliently, self-generation. While access to a generator allows firms to continue their operations during power outages, self-generation implies higher energy costs (Reinikka and Svensson, 2002) and sometimes even a weaker and more volatile power current. Furthermore, only some firms in developing regions have access to generators, depending on their size, degree of access to financing, and the dynamism of local markets (Steinbuks and Foster, 2010; Alby, Dethier,

Straub, 2011; Steinbuks, 2012). Other coping strategies may be as simple as running machinery at faster speeds in periods when grid electricity is available, or more elaborately, outsourcing production of intermediate inputs. Alam (2013) documented that some rice mills in India accelerated their production process by running the machines at higher speed when grid electricity was available. While this increased energy efficiency, it also increased wastage of unprocessed rice, the main variable input, thus reducing overall productivity. Fisher-Vanden, Mansur, and Wang (2015), in turn, documented the case of energy-intensive firms in China, which outsourced production of intermediate inputs in their production processes, effectively substituting energy for materials, as a response to severe blackouts in the early 2000s.

This chapter contributes to the literature on how firms react to unreliable electricity supply by analyzing the relationship between outages and firm behavior. The most salient message is that electricity reliability is directly associated with employment and innovation. A one standard deviation increase in power outages was linked to a 3 percent reduction in the labor force. Furthermore, most of the lost jobs were permanent positions, not temporary. Firms may be firing more workers or hiring fewer if they are continuously exposed to power outages, but at any rate, these are lost jobs. Analyzing data by gender showed that the jobs were lost almost exclusively among female workers. There was some variability across countries, but job shedding in the median firm amounted to roughly US$40,000 per year in lost wages. Workers, and apparently female workers, footed the bill of power outages.

Next, I analyzed the effect on innovation. The main finding was that firms with higher exposure to outages were less likely to introduce innovations in goods or services, but this effect was concentrated among firms with access to generators. A one standard deviation increase in outages was associated with a 10 percent reduction in the likelihood of introducing innovation in goods or services among these firms. This is consistent with firms allocating resources to self-generation that would have been allocated to innovation. Given the importance of innovation on firm growth, this finding suggests that unreliable power supply may have long-term consequences on firm performance and industry development.

The usual problems of endogeneity arise, so, to estimate the effects on firm outcomes, I relied on the panel structure of the dataset and included firm fixed effects, together with evidence that showed outages in the study sample were not related to lagged firm characteristics. Since firms were exposed to outages irrespective of their main observable characteristics (e.g., revenues, wage bill, number of employees, and other expenditures, as detailed in the main text), I argue that systematic differences reported in the follow-up survey arose, to a large extent, as a result of outages. Although it is impossible to control directly for unobservable variables like manager skills, it is reasonable to argue that revenues are a function of such variables. Hence, revenues work as a proxy for these unobservable variables. This procedure, in the same spirit as the "treatment balance" test in experimental studies, gave some support to the argument that differences in current outcomes were largely due to outages.

Data and Context

The data for this study come from the 2010 Latin American and Caribbean Enterprise Survey (LACES) and its 2014 follow-up, the Productivity, Technology, and Innovation (PROTEqIN) Survey, which targeted 1,680 LACES respondents to get new information on the original questions and to get additional information on firm performance, innovation, and management style, among other variables.

The main summary statistics are presented in Table 7.1. Of note, since the Dominican Republic was not included in the PROTEqIN survey, these firms were not taken into account for the main analysis. Including the Dominican Republic, two-thirds of the firms in the LACES survey reported experiencing power outages in 2010, with an average duration of 12.7 hours per month. Firms in the Dominican

TABLE 7.1. Summary Statistics

	LACES 2010	PROTEqIN 2014
Experienced outage (%)	77.48	77.01
SD	41.78	42.09
Outage hours per month	5.64	5.33
SD	15.87	16.92
Median	2	2
Hours of operation per week	62.65	73.64
SD	30.20	32.11
Median	50	65
Capacity utilization (%)	74.39	73.26
SD	11.88	14.10
Median	75	72
Employees	59.07	60.59
SD	132.27	124.55
Median	22	23
Permanent employees	53.00	55.56
SD	117.25	115.58
Median	20	21
Temporary employees	14.24	5.02
SD	48.77	22.56
Median	4	0
Female employees (permanent)	19.64	18.47
SD	49.77	50.67
Median	6	6
Male employees (permanent)	24.42	37.09
SD	53.06	76.17
Median	10	13
Access to generator (%)	43.02	41.66
SD	0.50	0.49

Source: LACES and PROTEqIN surveys.

Republic reported average outages of 61.2 hours, so restricting the sample to countries that appeared in both surveys, average power outages decreased to 5.6 hours per month. Perhaps as a result of this, 37 percent of firms classified electricity as a major or very severe obstacle to their business operations in LACES (35 percent omitting the Dominican Republic). Surprisingly, this figure is higher than corruption (31 percent), access to financing (33 percent), crime (30 percent), and unfair competition from the informal sector (26 percent).

By 2014, 77% of firms in the PROTEqIN survey still reported experiencing outages, but average outage duration decreased to 5.3 hours per month. This represents a 5 percent reduction compared to the LACES figure, excluding the Dominican Republic. Perhaps partly due to this reduction, the share of firms reporting electricity as a major or very severe obstacle declined to 27 percent, suggesting that although some progress had been made, there was ample room for improvement.

Unreliable access to electricity negatively affects profits and productivity. For instance, it induced some firms to buy or share generators, which produce electricity at a higher cost than grid electricity. LACES data suggests that on average 16 percent of electricity was generated by generator, and that 43 percent of firms owned or shared a generator. The PROTEqIN figure was slighting lower at 42 percent, but the share of electricity generated by this method decreased to 10 percent. This suggests that firms may be holding on to their generators to insure against power outages, but that the generators are being used less frequently as a consequence of improved reliability of electricity.

Empirical Approach

Estimating Equations

The main reduced-form estimating equation was:

$$\gamma_{it} = \alpha + \delta\, outage_{it} + \gamma_t + \mu_i + \varepsilon_{it} \qquad (1)$$

where y indicates the outcome of interest for firm i in year t, outage is monthly hours of power outage, γ_t and μ_i, are time and firm fixed effects, respectively, and ε_{it} is a disturbance term. Standard errors are clustered at the country level. This specification allowed all time-invariant firm characteristics to be controlled for.

Given that some questions were added in the PROTEqIN survey, analysis of covariance was used

instead of the fixed-effects model. The estimating equation was:

$$\gamma_i = \alpha + \delta\, outage_i + \beta_1 X_{i0} + \beta_2 N_{i0} + \varepsilon_i \qquad (2)$$

where X_{i0} includes the lagged value of the outcome of interest *y* if that variable was available in LACES, and N_{i0}=1 if the firm was not included in LACES. In particular, X_{i0} included lagged revenues, economic sector, and country fixed effects. Together, these variables accounted for the most important firm characteristics. In particular, controlling for country, sector, and differences in revenues was a proxy for differences in firm size, manager characteristics, and productivity, among others. The main advantage of this procedure was that it allowed variables that were not part of LACES to be included, while estimating the firm-fixed effects model would have required dropping them. Equation 1 was used for revenues and employment (total, permanent, temporary, male, and female). Equation 2, on the other hand, was used for regressions with hours of work, capacity utilization, and the innovation variables as dependent variables.

The Issue of Causality

Given the lack of plausibly exogenous variation in outages, the estimates provided in this chapter are not causal. However, I argue that, despite the fact that the model did not allow the magnitude of the coefficients to be specified, it is still possible to conclude that electricity shortages in fact affect firm outcomes. The conditional independence assumption (Angrist and Pischke, 2008: 52) needs to be relied on to interpret the results as causal. This assumption is formally stated as:

$$Y_{it} \perp outage_{it} \mid X$$

Controlling for a set of covariates X_{it}, potential outcomes of firm *i* are independent of the level of outages the firm experienced. To understand this expression intuitively, think of a firm in the PROTEqIN survey (2014), its employment level, and its exposure to outages. Now, imagine the value of employment the firm would have reported if it had been exposed to a different level of outages in the same year. This imaginary value is called a potential outcome. To infer causality, it is necessary to find firms with similar potential outcomes. Now, think of firms from the same country and economic sector. These firms share many common characteristics, but there are clearly wide differences among them, so they are unlikely to have similar potential outcomes. Beyond country and sector, firms differ in manager skills, labor force (in size as well as human capital), access to financing and to international markets, and so on. Two firms that share all these characteristics may indeed have similar potential outcomes. Though it is not possible to observe each of these variables individually, it is possible to observe one that summarizes them all: revenues. If revenues are a function of all these variables, it can be argued that firms from the same country and sector, and with the same revenues, have similar potential outcomes. Thus, controlling for revenues should satisfy the conditional independence assumption. Since revenues and outages are determined simultaneously, the regressions control for lagged revenues.

In addition, Table 7.2 shows that, controlling for country and sector, monthly outage hours in 2014 were not related to lagged firm characteristics. This means that firms that in 2014 were highly exposed to outages looked almost the same in 2010 as firms that in 2014 would be less exposed to outages. Since there were no systematic differences in the earlier period, it could be argued that a substantial portion of the systematic differences in 2014 were to a large degree due to differential exposure to outages. Each cell in Table 7.2 shows the coefficient of a regression of lagged firm characteristics, as indicated in the column headers, on outages. The key message is that outages in 2010 had no relation to firm characteristics in 2014. Outages were uncorrelated with lagged revenues, hours of operation, capacity utilization, or the number of employees. In addition, outages were uncorrelated with the number of temporary or permanent

TABLE 7.2. Power Outages and Lagged Firm Characteristics

Panel A: Main characteristics				
	(1) Revenues	(2) Hours of work	(3) Capacity	(4) Employees
Power outages	0.1615	−0.0035	−0.0426	0.0017
	(0.1884)	(0.0019)	(0.0303)	(0.0022)
Number of firms	1,720	214	205	1,886
Mean dep. var.	0.034	63.785	74.205	54.411
Panel B: Labor force				
	(1) Temporary	(2) Permanent, males	(3) Permanent, females	(4) Fem/male ratio
Power outages	0.0036	−0.0022	0.0168	0.1828
	(0.0103)	(0.0037)	(0.0100)	(0.1281)
Number of firms	812	1,617	1,617	1,601
Mean dep. var.	11.494	24.936	19.992	1.424
Panel C: Expenditures				
	(1) Wages	(2) Electricity	(3) Fuel	(4) Materials
Power outages	0.0596	0.7191**	−0.2277	−0.2289
	(0.2149)	(0.2597)	(0.2659)	(0.3095)
Number of firms	1,729	620	543	576
Mean dep. var.	0.04	0.034	0.037	0.03

Source: LACES and PROTEqIN surveys.
Notes: All regressions controlled for country and sector fixed effects. Power outages are measured as monthly hours of outages from the PROTEqIN data. The dependent variables are those indicated in the columns. Standard errors were clustered at the country level. Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

workers or their gender. Panel C shows the result of a test of additional firm characteristics. Lagged wages, fuel expenditures, and expenditures on materials showed no relation to outages. The only statistically significant relationship was between outages and lagged electricity bill. Firms that used more electricity in 2010 were more likely to suffer outages in 2014. To account for this difference, all analysis of covariance regressions (Equation 2) included lagged electricity expenditures as a control variable.

Despite being a somewhat encouraging result, the lack of systematic differences in lagged observable characteristics by exposure to outages did not offer a solution to the problem of double causality, which was another potential source of bias in OLS. This issue was especially important because outages may have depended on current production and, hence, indirectly on the outcome variables of interest. However, this reverse channel of causality implies a positive relationship between employment and outages, since firms that produce more—and thus require higher employment—demand more electricity and cause outages. Since the results indicate a negative relationship, reverse causality would be playing against the hypothesis, thus our estimates would be interpreted as a lower bound of the true effects of outages on firm behavior.

Results

The sample standard deviation of outages was 16.4 hours, but this was due mostly to a handful of large values (17 firms reported more than 50 hours

of outage). Hence, I used a conservative estimate of the standard deviation of the distribution after trimming values above two and above three standard deviations, which reduced the value of a standard deviation to 6.0 or 6.7 hours, respectively. To err on the modest side, a "standard deviation" unit was taken as 6.0 hours.

Table 7.3 shows that revenues were not altered significantly by power outages—consistent with Figure 7.1.[1] Firms reacted to outages by reducing employment. The average outage duration was

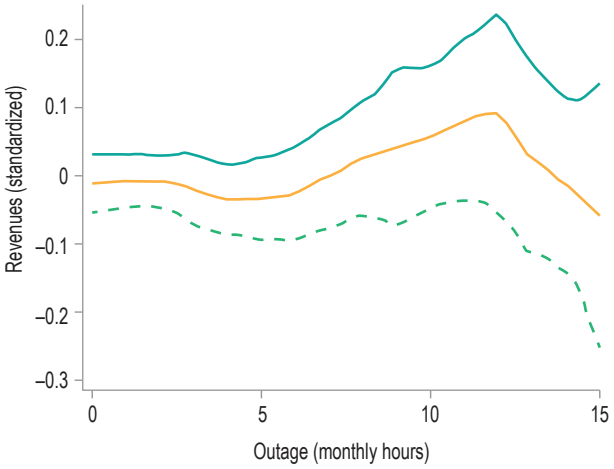
[1] All monetary variables were standardized by country and year.

TABLE 7.3. Outages and Firm Outcomes

Panel A: Main regression				
	(1) Revenues	(2) Employment	(3) Hours	(4) Capacity utilization
Power outages	0.0005	−0.3356**	−0.1618	−0.0869
	(0.0005)	(0.1464)	(0.0477)	(0.0487)
Firm FE	Yes	Yes	No	No
Year FE	Yes	Yes	No	No
Country FE	No	No	Yes	Yes
Sector FE	No	No	Yes	Yes
Lagged controls	No	No	Yes	Yes
Number of firms	2,395	2,458	890	872
Mean dep. var.	−0.002	59.1	71.2	73.4
Panel B: By generator ownership				
	(1) Revenues	(2) Employment	(3) Hours	(4) Capacity utilization
Power outages	−0.0009	−0.1554*	−0.1216	0.0174
	(0.001)	(0.086)	(0.0872)	(0.1127)
Power outages × generator	0.0017	−0.2364	0.0747	−0.1327
	(0.0011)	(0.1627)	(0.1106)	(0.1034)
Firm FE	Yes	Yes	No	No
Year FE	Yes	Yes	No	No
Country FE	No	No	Yes	Yes
Sector FE	No	No	Yes	Yes
Lagged controls	No	No	Yes	Yes
Number of firms	2,395	2,457	889	871
Mean dep. var.	−0.002	59.1	71.7	73.4
Marginal effect of outages for firms with access to a generator	0.001**	−0.392**	−0.047	−0.115***
	(0.000)	(0.152)	(0.049)	(0.014)
t-stat	2.186	−2.581	−0.959	−8.07

Source: LACES and PROTEqIN surveys.
Notes: All regressions controlled for country and sector fixed effects. Power outages are measured as monthly hours of outages reported in PROTEqIN. The dependent variables are indicated in the columns. Lagged controls were the standardized values of revenues and electricity expenditures as reported in LACES. Regressions on Hours and Capacity Utilization in Panel B included an indicator for access to a generator. Standard errors were clustered at the country level. *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

FIGURE 7.1. Revenues and Outages, Local Polynomials
(95 percent confidence bands)



Source: LACES and PROTEqIN surveys.

5.5 hours per month, implying that the average firm fired 1.8 employees as a direct consequence of power outages. This was equivalent to 3 percent of the labor force in the sample, a non-negligible figure. Consistent with this reduction, capacity utilization fell by 8.7 percentage points, suggesting important contractions in production. Hours of operation did not change significantly as a result of power outages.

These effects were more marked among firms with access to electricity generators. The marginal effect of outages on revenues was −0.002, which implies that a one standard deviation increase in outages reduced revenues by 0.012 standard deviations. The marginal effect on employment was −0.4, so a standard deviation increase in outages was associated with 2.4 fewer employees. These firms also cut capacity utilization more drastically: the marginal effect of outages was −0.115, and a one standard deviation increase was associated with a reduction of 0.69 percentage points in capacity utilization, or 1 percent of the average capacity utilization in the sample.

To gain a deeper understanding of the effects on employment, Table 7.4 disaggregates employment between permanent and temporary positions. Given the nature of their contracts, it is possible that firms keep permanent employees and fire temporary ones; however, this is not the only option. If firms are looking to access more flexible labor contracts, they may choose to fire permanent employees or to open fewer permanent positions. Alternatively, when firms decide to hire new employees, they may choose to hire more temporary workers. Table 7.5 shows that most of the effect of outages on employment was due to a reduction in the permanent workforce. A one standard deviation increase in outages eliminated 1.6 permanent jobs. Temporary jobs were not affected. The effect among firms with access to generators was higher, at 1.8 permanent jobs, and smaller among firms with no access to generators, where only one permanent job would be shed.

Table 7.5 takes the analysis a step further and disaggregates the effect on permanent employees by gender. Firms seem to have reduced female employment, but not male employment, in response to power outages. The female to male ratio decreased by 1.2 percent per hour of outage, amounting to an average reduction of 7.3 percent. When disaggregating firms by access to power generators, the pattern arose again: firms with access to generators cut more female jobs than those without. The marginal effect in the group with access to a generator was −0.07, while in the group without access, it was −0.40. A one standard deviation increase in outages was associated with 2.4 fewer females in permanent positions among firms with generators, and with 0.4 fewer females in permanent positions among firms with no access to generators. The female-to-male ratio decreased among this latter group by 7.2 percentage points.

Table 7.6 analyzes the relationship between outages and innovation. The dependent variables in all columns are dichotomous indicators of innovation, taking the value of 1 if the firm reported having innovated and 0 otherwise. Column 1 indicates whether the firm made a monetary investment in the previous two fiscal years. Column 2 indicates whether the firm introduced a new or improved good or service to the market in the three years leading to the survey. Column 3 indicates whether

TABLE 7.4. Outages and Employment

Panel A: Main regression				
	(1) Employment	(2) Permanent	(3) Temporary	(4) Permanent/temporary
Power outages	−0.3356**	−0.2646**	0.0014	−0.0218
	(0.1464)	(0.1057)	(0.0082)	(0.0353)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Number of firms	2458	2458	2168	1066
Mean dep. var.	59.1	53.6	7.9	11.9
Panel B: By generator ownership				
	(1) Employment	(2) Permanent	(3) Temporary	(4) Permanent/temporary
Power outages	−0.1554*	−0.1593*	−0.0016	0.0137
	(0.0860)	(0.0866)	(0.0048)	(0.0714)
Power outages × generator	−0.2364	−0.1398	0.0047	−0.0526
	(0.1627)	(0.1315)	(0.0083)	(0.0670)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Number of firms	2457	2457	2168	1066
Mean dep. var.	59.2	53.2	7.9	11.9
Marginal effect of outages for firms with access to a generator	−0.392**	−0.299**	0.003	−0.039
	(0.152)	(0.112)	(0.010)	(0.028)
t-stat	−2.581	−2.674	0.310	−1.400

Source: LACES and PROTEqIN surveys.
Notes: Regressions in Panel B included an indicator of access to a generator. Standard errors were clustered at the country level.
*Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

the firm introduced innovations in marketing its goods or services. Only the dependent variable in Column 2 appeared in both surveys, so it is possible to estimate Equation 1 only for this variable. For the others, Equation 2 was estimated.

Column 2 in Panel B shows that firms with generators were less likely to innovate the more they were exposed to power outages. A one standard deviation in outages was associated with a 1.2 percentage point reduction in the likelihood of innovation, which represents a 10 percent reduction with respect to the mean value in the PROTEqIN survey. The point estimates in the remaining columns were not statistically significant, but regrettably their confidence estimates were not tight enough to conclude that the effect was zero. For instance, the 95 percent confidence interval of the change in investment in innovation implied by one standard deviation in outages ranged from −0.01 to 0.02, implying a reduction of 8 percent or an increase of 16 percent with respect to the mean value.

Implications for Lost Wages

Based on the employment results above, the following investigates their potential implications for lost wages. Table 7.7 provides average and median salary, standard deviation of outage duration, and number of firms per country. These

TABLE 7.5. Outages and Employment

Panel A: Main regression				
	(1) Permanent employees	(2) Female	(3) Male	(4) Female/male
Power outages	−0.2646**	−0.3295*	0.0574	−0.0121**
	(0.1057)	(0.1694)	(0.0698)	(0.0041)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Number of firms	2458	2412	2412	2397
Mean dep. var.	53.6	18.9	30.1	1
Panel B: By generator ownership				
	(1) Permanent employees	(2) Female	(3) Male	(4) Female/male
Power outages	−0.1593*	−0.0720***	−0.1031	−0.0138
	(0.0866)	(0.0232)	(0.0961)	(0.0103)
Power outages × generator	−0.1398	−0.3261*	0.1987	0.0022
	(0.1315)	(0.1747)	(0.1396)	(0.0106)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Number of firms	2457	2411	2411	2396
Mean dep. var.	53.6	18.9	30.1	1
Marginal effect of outages for firms with access to generator	−0.299**	−0.398**	0.096	−0.012**
	(0.112)	(0.173)	(0.071)	(0.004)
t-stat	−2.674	−2.298	1.35	−2.801

Source: LACES and PROTEqIN surveys.
Notes: Regressions in Panel B included an indicator of access to a generator. Standard errors were clustered at the country level.
*Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

data allowed the total number of jobs lost due to outages to be estimated, as well as the economic loss workers faced. Table 7.7 shows that a one standard deviation reduction in outage duration could save between 1.5 (Trinidad and Tobago) and 6.0 (Jamaica) jobs per firm. The figure for Guyana was higher, at 17.5, but atypical, given its large standard deviation. On average, the region would save 5.5 jobs per firm from a one standard deviation reduction in outage duration.

PROTEqIN data allowed the mean wages in each firm to be estimated, as well as several percentiles of the wage distribution. These figures, together with the regression results, were used to estimate the income loss associated with outages. On average, a one standard deviation increase in outages reduced the wage bill by US$54,000 per firm. The lowest values were observed in Belize and Dominica (US$11,800 and US$11,900, respectively), while the highest loss was observed in Guyana (US$66,200).

Conclusions

This chapter studied how Caribbean firms responded to power outages. The main finding is that power outages were negatively associated with employment and, among firms with access to a generator,

TABLE 7.6. Outages and Innovation

Panel A: Main Regression			
	(1) Invested in innovation	(2) Goods	(3) Marketing
Power outages	0.0007	–0.0012	–0.0006
	(0.0011)	(0.0008)	(0.0008)
Firm FE	No	Yes	No
Year FE	No	Yes	No
Country FE	Yes	No	Yes
Sector FE	Yes	No	Yes
Lagged controls	Yes	No	Yes
Number of firms	1886	1886	1886
Mean dep. var.	0.174	0.123	0.123
Panel B: By Generator Ownership			
	(1) Invested in Innovation	(2) Goods	(4) Marketing
Power outages	0.0025	0.0026	0.0005
	(0.002)	(0.0025)	(0.0015)
Power outages*generator	–0.0028	–0.0049**	–0.0017
	(0.0023)	(0.0021)	(0.0017)
Firm FE	No	Yes	No
Year FE	No	Yes	No
Country FE	Yes	No	Yes
Sector FE	Yes	No	Yes
Lagged controls	Yes	No	Yes
Number of firms	1886	1886	1886
Mean dep. var.	0.174	0.123	0.123
Mg effect of outages for	–0.000	–0.002***	–0.001
firms with access to generator	(0.001)	(0.001)	(0.001)
t-stat	–0.231	–2.721	–1.196

Source: LACES and PROTEqIN surveys.
Notes: Regressions in Panel B included an indicator of access to a generator. Standard errors were clustered at the country level. *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

innovation. A one standard deviation increase in outages was associated with a 3 percent decline in employment. The evidence reviewed in this study suggests that the majority of these positions would be lost by women in permanent jobs. While nothing guarantees that reducing outages would increase female employment, the results suggest that preventing further job losses is likely to favor women, who at present have a higher risk of being fired. Using mean wages, the estimated annual reductions in the wage bill per firm amounted to roughly US$54,000, but the sample variation was considerable, with figures ranging from US$11,800 and US$11,900 in Belize and Dominica to US$66,200 in Guyana. These figures can be used as inputs in a cost–benefit analysis to determine the benefits of upgrading the power generation and distribution system to reduce outages.

There was also a strong negative association between power outages and innovation, concentrated among firms with access to generators. A one standard deviation increase in outages was associated with a 10 percent decline in the likelihood of introducing innovation in goods or services among firms with access to generators. Since innovation is a key driver of firm growth, this suggests that outages may have permanent consequences for firm performance and industry development.

A natural next step is to investigate why the relationship between power outages and employment more strongly affects female workers. PROTEqIN data indicate that firms with top female managers on average experience one additional hour of outages. Thus, it may be that some sectors are more affected by outages than others, and those have more female employees. So, it may be that firms that have a high proportion of female workers belong to specific sectors and are geographically clustered in locations that are more prone to outages. A more disaggregated geo-location of the firms would be needed to investigate whether they are geographically clustered. Then the issue to uncover would be why they are clustered there and what is preventing them from moving to better locations.

TABLE 7.7. Wages Lost to Outages *(× US$1,000)*

	SD outage	Jobs lost per firm	Wage (× US$1,000)				Implied reduction per firm (× US$1,000)			
			Mean	25%	50%	75%	Mean	25%	50%	75%
Antigua and Barbuda	6.00	2.01	12.0	5.6	8.6	13.6	24.2	11.3	17.4	27.5
Bahamas, The	8.24	2.77	16.7	7.6	12.8	20.0	46.3	21.0	35.4	55.3
Barbados	6.40	2.15	14.6	10.4	15.0	16.7	31.3	22.4	32.2	35.8
Belize	4.87	1.63	7.2	5.5	6.8	8.4	11.8	9.0	11.1	13.7
Dominica	4.67	1.57	7.6	5.3	6.6	9.1	11.9	8.3	10.3	14.2
Grenada	8.92	2.99	13.2	3.7	6.0	9.9	39.5	11.2	18.1	29.7
Guyana	52.06	17.47	3.8	1.7	3.1	5.1	66.2	30.0	53.5	89.5
Jamaica	17.86	5.99	7.0	4.1	5.5	8.0	42.2	24.7	32.8	47.7
Saint Lucia	5.23	1.76	7.0	4.1	6.2	8.0	12.2	7.2	10.9	14.1
St. Kitts and Nevis	11.27	3.78	7.9	4.8	6.6	9.1	29.9	18.0	25.0	34.4
St. Vincent and the Grenadines	4.99	1.68	9.6	5.7	7.4	9.4	16.1	9.5	12.4	15.8
Suriname	6.99	2.35	7.9	4.8	7.3	9.1	18.6	11.2	17.1	21.4
Trinidad and Tobago	4.52	1.52	12.6	5.9	9.0	12.3	19.1	9.0	13.6	18.7
Region	16.36	5.49	9.9	4.9	7.1	10.8	54.1	26.7	38.9	59.0

Source: PROTEqIN survey.

References

Adenikinju, A. 2005. "Analysis of the Cost of Infrastructure Failures in a Developing Economy: The Case of the Electricity Sector in Nigeria." AERC Research Paper 148. Nairobi: African Economic Research Consortium.

Alam, M. 2013. "Coping with Blackouts: Power Outages and Firm Choices." Working Paper. New Haven, CT: Yale University.

Alby, P., J. Dethier, and S. Straub. 2011. "Let There be Light! Firms Operating under Electricity Constraints in Developing Countries." Working Paper. Toulouse, France: Toulouse School of Economics.

Allcott, H., A. Collard-Wexler, and S. O'Connell. 2015. "How Do Electricity Shortages Affect Industry? Evidence from India." *American Economic Review* 106(3):587–624.

Angrist, J., and J. Pischke. 2008. *Mostly Harmless Econometrics: An Empiricist's Companion.* New Jersey: Princeton University Press.

Barron, M., and M. Torero. 2015a. "Household Electrification and Indoor Air Pollution." Unpublished manuscript.

____. 2015b. "Short-Term Effects of Household Electrification." Unpublished manuscript.

Beenstock, M., E. Goldin, and Y. Haitovsky. 1997. "The Cost of Power Outages in the Business and Public Sectors in Israel: Revealed Preference vs. Subjective Valuations." *The Energy Journal* 18(2): 39–61.

Bensch, G., J. Kluve, and J. Peters. 2010. "Rural Electrification in Rwanda: An Impact Assessment Using Matching Techniques." *Ruhr Economic Papers* 231.

Chakravorty, U., M. Pelli, and B. U. Marchand. 2013. "Does the Quality of Electricity Matter? Evidence from Rural India." *Journal of Economic Behavior & Organization* 107:228–47.

Dinkelman, T. 2011. "The Effects of Rural Electrification on Employment: New Evidence from South Africa." *American Economic Review* 101(7):3078–108.

Fisher-Vanden, K., E. Mansur, and Q. Wang. 2015. "Electricity Shortages and Firm Productivity: Evidence from China's Industrial Firms." *Journal of Development Economics* 114:172–88.

Foster, V., and J. Steinbuks. 2009. "Paying the Price for Unreliable Power Supplies: In-House Generation of Electricity by Firms in Africa." World Bank Policy Research Paper 4913. Washington, DC: The World Bank.

Khandker, S. R., D. F. Barnes, and H. A. Samad. 2012. "The Welfare Impacts of Rural Electrification in Bangladesh." *The Energy Journal* 33(1).

____. 2013. "Welfare Impacts of Rural Electrification: A Panel Data Analysis from Vietnam." *Economic Development and Cultural Change* 61(3):659–92.

Lipscomb, M., A. M. Mobarak, and T. Barham. 2013. "Development Effects of Electrification: Evidence from the Topographic Placement of Hydropower Plants in Brazil." *American Economic Journal: Applied Economics* 5(2):200–31.

Reinikka, R., and J. Svensson. 2002. "Coping with Poor Public Capital." *Journal of Development Economics* 69:51–69.

Rud, J. 2012. "Electricity Provision and Industrial Development: Evidence from India." *Journal of Development Economics* 97:352–67.

Ryan, N. 2013. "The Competitive Effects of Transmission Infrastructure in the Indian Electricity Market." Working Paper. Cambridge, MA: Massachusetts Institute of Technology.

Steinbuks, J., and V. Foster. 2010. "When Do Firms Generate? Evidence on In-House Electricity Supply in Africa." *Energy Economics* 32:505–14.

Steinbuks, J. 2012. "Firm's Investment under Financial and Infrastructure Constraints: Evidence from In-House Generation in Sub-Saharan Africa." *The B.E. Journal of Economic Analysis & Policy* 12(1):1–34.

8

Assessing the Impact of Innovation and Business Development Programs in the Caribbean

Federico Bernini, Lucas Figal Garone, and Alessandro Maffioli

Long-term productivity growth is a crucial determinant of sustainable growth and development. Substantial research has been devoted to the search for the sources and determinants of productivity, and it is increasingly acknowledged that it is not possible to foster growth by perfecting domestic markets and liberalizing international transactions alone; some form of active public policy is needed. In this sense, innovation is widely considered to be a primary source of economic growth, and policies to encourage firm-level innovation and business development are high on the agendas of most developed economies and those that are successfully catching up. Also, many Latin American countries are increasingly committing to collective actions to build capacity, knowledge production, and technological innovation.

The theoretical justification for active interventions with regards to innovation and productive development policies is based on the concepts (and evidence) of market and coordination failures. In response, several Latin America and Caribbean (LAC) countries have put into place an increasingly complex set of programs and instruments (Agosin, 2013; Melo and Rodríguez-Clare, 2006). Indeed, multiple productive development programs (PDPs) are in place to enhance productivity, including the following:

- Business development programs such as extension and technical assistance programs, support to adopt quality control and certification, training in information technology and management best practices, and support for marketing and logistics.
- Business linkages programs such as supplier development programs, clusters, and value chains.
- Business innovation programs such as research and development (R&D) subsidies, technology adoption funds, R&D tax credits, and university–industry collaboration.

- Export and investment promotions, such as international trade fairs, technical assistance and training for exporting, and tax incentives to attract foreign direct investment (FDI).
- Entrepreneurship development programs such as support for seed capital, angel investor networks, incubators, and venture capital.
- Programs to facilitate long-term financing.

Moreover, at least for the largest countries in the region, several of these PDPs are managed at different levels of government—national, provincial, and even municipal.

Given that, on average, LAC countries exhibit lower productivity growth rates than other developed and developing countries, and that public intervention is a basic ingredient in enhancing firm productivity, program evaluation is an essential contribution to policy learning and decision-making. The Inter-American Development Bank (IDB) is strategically relevant for external evaluation of policy interventions aimed at supporting innovation and enhancing the competitiveness of firms in general and small and medium enterprises (SMEs) in particular.

In contrast with the situation in developed countries, few PDP programs have been rigorously evaluated in LAC. Until very recently, such evaluations mostly relied on beneficiary satisfaction surveys or simple case studies that, although interesting, cannot assess whether a program is actually working. Fortunately this situation has evolved and, since the mid-2000s, an increasing number of studies and evaluations have analyzed the effectiveness of PDPs in LAC more rigorously. The IDB has contributed significantly to this growing literature, in particular in the areas of innovation and export promotion policies. Since 2005, the IDB Evaluation Office, the Strategy Development Division, and the Competitiveness and Innovation Division have evaluated the impact of innovation and research policies in Argentina, Brazil, Chile, Colombia, and Panama. In 2008, The World Bank, building on previous IDB work, carried-out the "Impact Evaluation of Small and Medium Enterprise Programs in Latin America and the Caribbean" project, which assessed the impact of some of these programs in Mexico, Chile, Colombia, and Peru (Acevedo and Tan, 2011).[1]

In the Caribbean, the evidence on the effectiveness of PDPs is even more scarce. In this context, Compete Caribbean's 2013 Productivity, Technology, and Innovation (PROTEqIN) survey provides data that can help shed some light on the potential effects of PDPs on firm performance in Caribbean countries. This is a firm-level survey of a representative sample of the economy's private sector. The survey covers a broad range of business environment topics, including performance measures, innovation, access to financing, competition, labor and skills, and public support. Of particular relevance is the module on business strategy and support programs. This module contains information on firms' participation in business development and innovation programs that can be used to analyze the effects of technical assistance, technology adoption, and innovation programs on firm performance. For this purpose, the survey identifies different variables of program participation (treatment), constructs several measures of productivity (labor productivity and total factor productivity, or TFP) as main indicators of performance, and uses a large number of covariates to control for selection into the PDPs.

This chapter describes the performance of Caribbean firms and the effectiveness of the PDPs intended to improve performance. We characterize what kinds of firms are participating or not participating in the different programs. This analysis can help answer some questions about PDPs. Are the participating firms the right target? Are firms aware of these kinds of programs? What is the potential demand for such programs?

We inquire about the main sectors and areas in which firms are more likely to use these programs.

[1] See Benavente et al. (2012), Figal Garone et al. (2014), Castillo et al. (2015), Crespi et al. (2015), Castillo et al. (2016), Figal Garone and Maffioli (2016), and the references therein cited, for recent evaluations of PDP in LAC.

This is important because such information could be helpful in readapting the programs (if necessary) to cover the needs of firms and to better target them. We then review the effect of PDPs on intermediate outcomes with short-term impact, such as innovation spending and training. We look at the association between these intermediate outcomes and productivity measures that we would expect to have a long-term effect. Finally, we see whether these PDPs affect the probability of successfully improving performance measures such as reduced costs or increased sales.

While this study did not make it possible to define causal parameters that could strongly confirm the existence of a relationship between several variables, we sought to generate ideas to begin discussions and research to find effective ways to promote innovation and development in Caribbean firms.

Literature Review

There is a large body of literature that emphasizes the importance of productivity in driving development. Robert Solow (1956) introduced a new way to think about economic growth, disaggregating it into different components. A country can produce more with factor accumulation (increasing the level of capital and labor or improving human capital) or by increasing TFP. Several papers have shown the importance of TFP, highlighting that, in the long run, it is the main source of growth in GDP per capita.

In the past 50 years, growth in LAC's per capita income has been low relative to developed countries. IDB (2014) demonstrated that this is not due to poor factor accumulation. Growth in physical and human capital of a typical Latin American country has been similar to that of the United States. The problem is related to the poor growth in TFP, which has led to an increase in the productivity gap with developed countries.

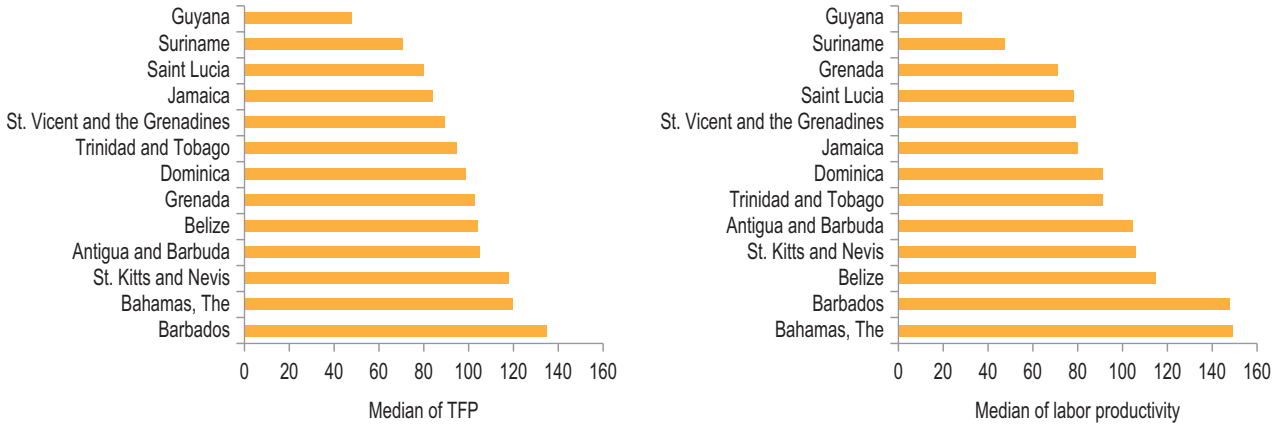
No real improvement has been seen in recent years. The World Bank (2014) analyzed productivity in LAC for the period from 2006 to 2010. It documented negative labor productivity growth over this period for both manufacturing and services firms. Particularly, Caribbean countries performed worse than the rest of the region in both sectors, increasing their disadvantages. Therefore, promoting a development agenda for LAC implies boosting productivity as well. Productivity is one of the challenges that the region must face in coming decades.

How can countries increase their productivity? Two common measures of productivity growth are innovation expenditures and training programs. However, the existence of market failures is one of the main reasons why firms' investments in these activities tend to be lower than the socially optimal value. So, public intervention to boost innovation spending is a necessary productive development policy. Benavente, Crespi, and Maffioli (2007) analyzed a program that financially supported the innovation activities of firms in Chile. They found that subsidies partially crowded out private investments in innovation and that they more effectively promoted technological upgrades and process innovations than radical product innovations. Subsidies also induced changes in the innovation strategies of firms.

Along the same line of research, Hall and Maffioli (2008) found that the effectiveness of Technology Development Funds depends on the financial mechanism used, the presence of firm–university interaction, the presence of non-financial constraints, and the characteristics of the target beneficiaries. They also found that participation in these programs induced a more proactive attitude toward innovation activities, increased innovative output, and improved performance.

Complementing this literature, López-Acevedo and Tinajero (2010) found evidence that in Mexico the participation of SMEs in support programs improved key performance variables—even promoting exports. This is an important result because it is common to find that SMEs provide an important portion of employment. So, when SMEs see improvements, a big portion of the economy is improving as well.

FIGURE 8.1. TFP and Labor Productivity by Country



Source: Authors' calculations based on PROTEqIN survey.

Such studies are part of a growing body of literature that demonstrates the importance of implementing innovation programs. Evidence suggests that innovation is a way of closing the productivity gap (Griffith, Redding, and Van Reenen, 2004). This chapter aims to incorporate evidence about PDPs in Caribbean countries. Mainly, we wanted to know what kinds of firms are involved (and not involved) in PDPs, what programs they participate in, and which ones most effectively improve firm performance.

Description of Caribbean Productivity

In this section, we characterize productivity in Caribbean countries. Figure 8.1 shows firm TFP and labor productivity[2] for each country.

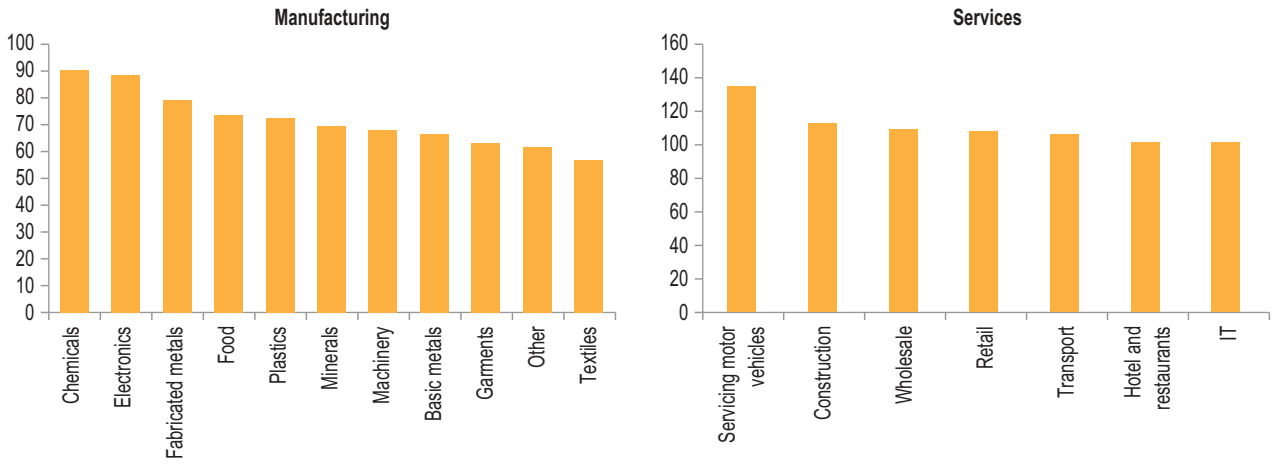
Figure 8.1 shows that the countries with productivity levels in the middle of the range are similar, with a slightly larger difference from the most productive countries (Barbados, The Bahamas, and St. Kitts and Nevis) and from the least productive country (Guyana). Therefore, it seems that low levels of productivity are an issue experienced by almost all countries. Figure 8.2 shows productivity by sector (manufacturing or services) and industry.

The disaggregation shown in Figure 8.2 provides an interesting picture of productivity in the Caribbean. First, there is more heterogeneity in the productivity levels of manufacturing firms than of firms in the services sectors. Second, some sectors are clearly more productive than others. In manufacturing, firms in the chemicals and electronics sectors are the most productive, while textile firms are the least productive. In services, firms that service motor vehicles are the most productive, while hotels and restaurants are the least productive. Finally, Figure 8.2 shows that the least productive services sector is still more productive than the best sector in manufacturing. So, it seems that part of the productivity problem in Caribbean countries is in manufacturing.

Figure 8.2 shows the productivity of the median firm in each industry, which could bias the analysis if there are many small, unproductive firms and a few big, productive firms in each industry. Therefore it may be that a big firm that can concentrate more resources is more representative of the industry than many small firms that together still may have fewer resources. To address this problem, we constructed two new figures to show aggregate productivity, a weighted mean of productivity in each industry. The

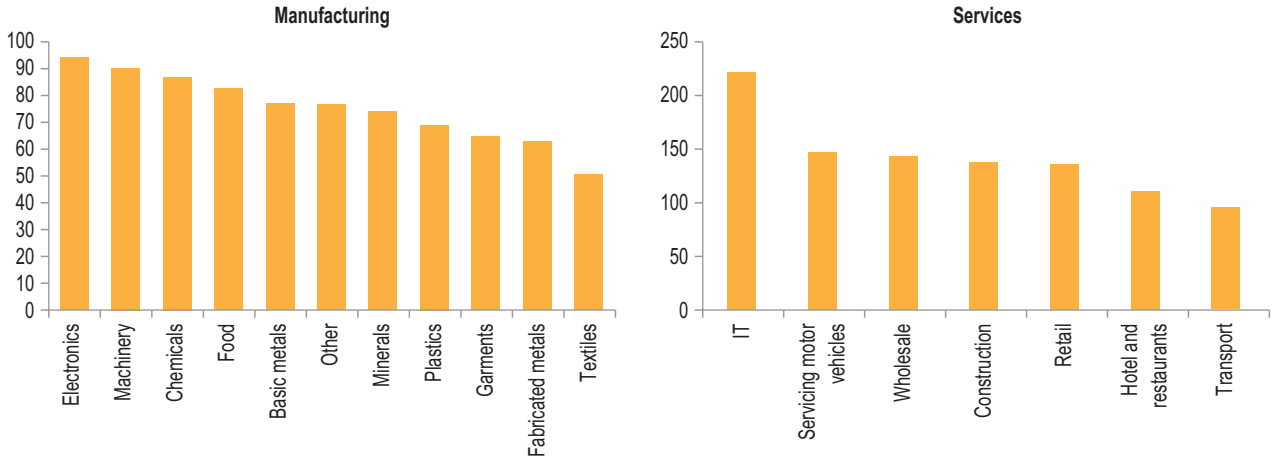
[2] TFP was estimated with industry shares and labor productivity as value added per employee, but the results were robust to the use of other shares, such as country or industry–country shares for TFP estimates, and sales per employee for labor productivity estimates.

FIGURE 8.2. TFP by Sector and Industry



Source: Authors' calculations based on PROTEqIN survey.

FIGURE 8.3. Aggregate Productivity by Sector and Industry



Source: Authors' calculations based on PROTEqIN survey.

weights refer to the number of workers in each firm relative to the total employees in the industry.

Figure 8.3 confirms some of the trends shown in Figure 8.2—services firms are still more productive and homogenous than manufacturing firms. However, on this weighted aggregate basis, IT is much more productive than the rest of the services industries, which is curious since IT was one of the least productive services industries based on the previous measure. The difference may be related to how the firms are weighted since small unproductive firms are lower weighted than the few big productive firms, which are higher weighted. In manufacturing, the inverse is true for fabricated metal products. Based on the median measure, fabricated metals is one of the most productive industries; however, based on aggregate productivity, it is one of the least productive. It could be that there are a few small, productive firms (which are lower weighted) and many big unproductive firms (which are higher weighted). The rest of the industries in each sector

are ordered similar to the previous measure. Based on this measure, services are still more productive than manufacturing.

What Kinds of Firms Are Involved (and Not Involved) in PDPs?

The focus of this chapter is evaluating how PDPs are working in Caribbean countries. Understanding how such programs are working provides information about whether support is reaching target firms (and industries) and the impact they are having on its performance. Problems identified in this analysis will be useful in readapting programs to make them more efficient. Benefits can be a guide for what elements should be further enhanced.

The first step in making a PDP successful is making companies aware of its existence, which may increase the likelihood that target companies participate in the program. So, first we analyzed which kinds of firm are and are not aware of PDPs. Table 8.1 looks at various characteristics of firms that are aware or not and shows whether the mean differences are statistically significant.

Table 8.1 shows that firms that are aware of the program are bigger and more likely to export. They also have a higher percentage of skilled workers and are more likely to provide employee training. There are no significant differences in performance measures. This preliminary result is interesting because it suggests that firms that are not aware of PDPs have fewer skilled workers and do not train them to reverse this situation.

It is also interesting to see what percentage of firms were aware of PDPs and how they are distributed. Table 8.2 differentiates awareness levels by country and sector.

There is some heterogeneity in this measure; however, most countries show awareness levels of over 50 percent (particularly in manufacturing), but a few show a significantly lower level. Moreover,

TABLE 8.1. Characteristics of Aware and Not Aware Firms

	Not aware	Aware	Difference
Employees (#)	49.56	59.76	−10.20**
Export (% of firms)	0.19	0.23	−0.04**
Foreign (% of firms)	0.16	0.15	0.003
Skilled (% of employees)	0.26	0.30	−0.03***
Age (years)	25.55	25.01	0.54
TFP1	4.52	4.55	−0.03
TFP2	4.37	4.46	−0.09
TFP3	4.55	4.53	0.02
Value added per employee (US$)	41,746	41,726	20.01
Sales per employee (US$)	69,933	73,979	−4,045
Innovation spending (US$)	40,716	69,279	−28,562
Capital (US$ millions)	24.9	33.1	−8.2
Training (% of firms)	0.43	0.66	−0.23***

Source: Authors' calculations based on PROTEqIN survey.
Notes: *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

TABLE 8.2. Percentage Awareness of Program by Country and Sector

	Sector	
	Manufacturing	Services
Antigua and Barbuda	80.77	79.05
Bahamas, The	63.64	64.89
Barbados	55.56	46.38
Belize	38.60	43.08
Dominica	77.27	80.77
Grenada	71.43	61.11
Guyana	34.88	20.78
Jamaica	68.03	43.54
Saint Lucia	71.93	78.87
St. Kitts and Nevis	67.86	55.67
St. Vincent and the Grenadines	73.81	75.82
Suriname	28.79	29.63
Trinidad and Tobago	71.55	61.61

Source: Authors' calculations based on PROTEqIN survey.

there is heterogeneity within some countries. For example, 35 percent of manufacturing firms in Guyana know about PDPs while only 21 percent of services firms are aware of them. However, between-country variability seems to be more important than within-country variability.

Once we understood how aware firms were about PDPs, it was important to know about participation. For an overview of companies participating in programs, we replicated the awareness analysis. The results are shown in Table 8.3.

Descriptive statistics of participating and nonparticipating firms show that they are quite similar. Only four variables were significantly different. Participating firms were bigger, more likely to export, nationally owned, and more likely to train their employees. However, performance measures, percentage of skilled workers, and age of the firm were similar between the two groups. Also, they were similar on capital and innovation expenditures.

We also replicated the analysis of percentage of firms participating in PDPs and the distribution between and within countries. The results are shown in Table 8.4.

The pattern for participation by country and sector (Table 8.4) is similar to that for awareness (Table 8.2), but the levels of participation are significantly lower than the levels of awareness. Countries (and sectors) that were more aware of public programs also had higher levels of participation, with some exceptions. The Bahamas showed good awareness, but had the lowest level of participation in programs to support both manufacturing and services. Suriname had the lowest level of awareness but a good level of participation relative to other Caribbean countries. So, to be aware seems important to firm participation, but it is not the only factor. The next sections focus on characterizing what kinds of companies participate in PDPs and which do not.

TABLE 8.3. Characteristics of Participating and Not Participating Firms

	Not participating	Participating	Difference
Employees (#)	53.63	65.25	−11.62**
Export (% of firms)	0.20	0.25	−0.05**
Foreign (% of firms)	0.16	0.13	0.03*
Skilled (% of employees)	0.28	0.29	−0.01
Age	25.31	24.83	0.48
TFP1	4.54	4.57	−0.04
TFP2	4.44	4.33	0.11
TFP3	4.54	4.52	0.02
Value added per employee (US$)	42,659	37,160	5,499
Sales per employee (US$)	70,536	81,289	−10,752
Innovation spending	52,851	81,931	−29,080
Capital (US$ million)	29.8	29.6	0.2
Training (% of firms)	0.53	0.74	−0.23***

Source: Authors' calculations based on PROTEqIN survey.
Notes: *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

TABLE 8.4. Percentage Participation by Country and Sector

	Sector	
	Manufacturing	Services
Antigua and Barbuda	26.92	32.38
Bahamas, The	3.03	9.57
Barbados	20.37	20.29
Belize	14.04	16.92
Dominica	22.73	25.96
Grenada	14.29	12.96
Guyana	11.63	7.79
Jamaica	16.84	8.84
Saint Lucia	15.79	22.54
St. Kitts and Nevis	21.43	6.19
St. Vincent and the Grenadines	16.67	30.77
Suriname	15.15	18.52
Trinidad and Tobago	21.55	11.61

Source: Authors' calculations based on PROTEqIN survey.

Description of Non-participant Firms

It is important to know which companies participate in PDPs to support improvements in different areas, such as innovation. But it is also essential to know which companies are not participating and why not.

First, we identified which firms were interested in participating in a PDP. Table 8.5 shows several characteristics of firms, distinguishing between interested and not interested firms.

Table 8.5 shows that, of firms not participating in PDPs, the characteristics of interested and not interested firms were not statistically different in number of employees, firm age, or proportion of foreign and export firms. The main differences were in performance measures. For example, firms not interested in participating were more productive and spent more money on innovation than firms interested in participating. However, they had a higher proportion of skilled employees and provided their employees more training.

We also disaggregated the analysis and described interested and non-interested firms in terms of preferences. We began with firms that were interested in PDPs, asking what kind of program they would participate in. This information provided an idea of potential demand for PDPs. Table 8.6 shows what types of programs were of interest.

The comparison of firms interested in different areas for PDPs showed a number of interesting results. Firms that would participate in technology and innovation programs had the highest number of employees, more capital, and the most spending on innovation. Also, they were the most productive in terms of both measures of labor productivity—value added per employee and sales per employee. Firms that would participate in marketing and operations programs were the second youngest, had the fewest employees, the least amount of capital, and the second lowest spending on innovation. They were also the least likely to export and the least productive in terms of labor productivity. We did not find big differences in other characteristics, such as proportion of foreign firms and skilled workers, or in performance measures, such as the TFP estimates.

We were not only concerned with firms that wanted to participate in PDPs; we also wanted to know why firms did not want to be involved. Firms were asked why they were not interested in participating. The intention of gaining this information was to help policymakers readapt support programs (as necessary) to attract participants.

Table 8.7 characterizes the disinterested firms and the reasons for their lack of interest. Firms that considered PDPs too expensive were, on average, smaller and there was a higher proportion of national firms. Firms that indicated that the administrative procedure was cumbersome were the oldest firms, spent most on innovation, and had higher levels of capital and productivity. Those that indicated

TABLE 8.5. Characteristics of Interested and Not Interested Non-participant Firms

	Not interested	Interested	Difference
Employees (#)	53.91	55.19	−1.28
Foreign (% of firms)	0.16	0.16	0.00
Export (% of firms)	0.19	0.21	−0.02
Age (years)	25.05	25.60	−0.55
Skilled (% of employees)	0.59	0.62	−0.02***
TFP1	4.57	4.52	0.05**
TFP2	4.50	4.38	0.12*
TFP3	4.55	4.53	0.02
Value added per employee (US$)	50,799	38,028	12,771***
Labor productivity (US$)	83,391	63,881	19,510
Capital (US$ million)	35.2	29.2	6.1
Innovation spending (US$)	90,697	34,963	55,734*
Training (% of firms)	0.55	0.52	−0.03*

Source: Authors' calculations based on PROTEqIN survey.
Notes: *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

TABLE 8.6. Area of Interest for PDPs

	General management, business development, and strategies	Marketing and operations	Financial management, and tax and customs administration	Technology and innovation	Human resources
Employees (#)	44.20	36.21	54.65	69.48	47.42
Foreign (% of firms)	0.21	0.17	0.17	0.14	0.14
Export (% of firms)	0.23	0.14	0.22	0.22	0.24
Age (years)	26.01	23.87	25.52	27.54	21.72
Skilled (% of employees)	0.28	0.26	0.25	0.26	0.27
TFP1	4.48	4.51	4.55	4.53	4.56
TFP2	4.39	4.49	4.52	4.33	4.40
TFP3	4.44	4.53	4.54	4.53	4.59
Value added per employee (US$)	36,756	30,976	38,243	44,419	32,862
Sales per employee (US$)	59,856	51,799	62,085	74,449	54,730
Capital (US$)	33.9	7.8	25.6	59.7	9.7
Innovation spending (US$	29,231	26,561	95,323	99,871	23,560
Training (% of firms)	0.51	0.50	0.53	0.50	0.55

Source: Authors' calculations based on PROTEqIN survey.

TABLE 8.7. Main Reason for Disinterest

	Not needed	Too expensive	Used such assistance in past and wasn't useful	Administrative procedure is cumbersome	Too many strings attached	Not aware of such assistance and don't know its advantages
Employees (#)	56.44	38.95	61.79	55.51	64.94	45.00
Foreign (% of firms)	0.12	0.12	0.25	0.16	0.23	0.17
Export (% of firms)	0.20	0.20	0.14	0.24	0.19	0.17
Age (years)	24.91	23.72	25.33	27.23	19.98	26.74
Skilled (% of employees)	0.31	0.28	0.31	0.27	0.29	0.29
TFP1	4.47	4.60	4.63	4.62	4.82	4.55
TFP2	4.55	4.49	4.23	4.50	4.46	4.67
TFP3	4.55	4.56	4.41	4.46	4.62	4.67
Value added per employee (US$)	44,861	46,173	50,224	69,673	78,442	37,985
Labor productivity (US$)	71,033	77,392	86,448	106,480	139,649	61,452
Capital (US$ millions)	27.8	2.4	6.7	78.8	3.2	80.8
Innovation spending (US$)	33,044	110,178	5,128	396,834	16,726	48,905
Training (% of firms)	0.51	0.65	0.62	0.62	0.67	0.38

Source: Authors' calculations based on PROTEqIN survey.

there were too many strings attached were the most productive, the youngest, and had the most employees. Finally, firms that indicated that they did not need public support or they were not aware of this type of assistance and did not know its advantages were the least productive, spent a medium amount on innovation, and had the lowest proportion of training programs for their employees.

These tables show that firms that were interested in participating in a PDP for innovation were also the firms that spent more money on innovation, had more capital, and were more productive. Moreover, within the firms not interested in participating, those that argued that they were not aware of this type of assistance, did not know about its advantages, or did not need this kind of program were also the least productive, spent less on training, and had lower levels of capital. Thus, lack of interest may be a result of firms not understanding the benefits of innovation in and of itself.

Determinants of Participation

After characterizing firms that participated in public support programs and those that did not and those that were interested and those that were not, we wanted to figure out the determinants of participation in PDPs. The goal of understanding the determinants of participation was to find out whether targeted firms are those actually participating. Table 8.8 shows the regression estimates.

We ran different estimations looking for different relationships. First, we wanted to see whether firm characteristics partially explained participation. The number of employees had a positive and significant association with program participation; an additional employee was associated with 0.02 percentage points in the probability of participation. In addition, foreign firms had a lower participation rate by more than 4 percentage points. However, there were no significant effects of age or a firm's export position.

In the remaining estimates, we exploited different variables to help understand why a firm decided (or not) to participate. For example, firms were asked if they paid less tax than they were required to. We found that those firms that admitted to having paid less tax participated in PDPs by 3 percentage points lower. This result was expected since firms that avoid taxes do not want to participate in programs for fear of an audit, which would be more damaging than the benefits they perceive of a PDP. However, the result led to the discussion of how rigorous governments should be with tax regulations. On one hand, strict regulations can encourage firms to formalize, increasing the opportunity cost of evading taxes. On the other hand, governments want to promote productivity and being very strict with regulations may restrict the success of this goal.

We also wanted to know whether there was any link between participation in a PDP and various measures of a firm's relationship with the government. The dataset has several questions that make it possible to identify whether an inspector expected a gift or an informal payment from a firm (a corruption measure) or if it had a formal contract with the government. Neither variable had a significant impact on the probability of being part of a PDP. Moreover, we saw that applying for an import license had no significant effect on the probability of a firm participating. So, we did not find any corruption mechanism by which firms could obtain advantages to participating in PDPs.

Then, we inquired about the possibility that companies that had senior managers spending more time on requirements imposed by government regulations were less likely to participate in PDPs. We found no significant association. Finally, we looked for a relationship between firm structure and the probability of participating in PDPs. Intuitively, companies with more departments may have a department responsible for applying to such programs. But we found no significant effect.

Female Discrimination

Another element of the dataset that we exploited was the part of the questionnaires where firms were asked about gender characteristics. Following

TABLE 8.8. Determinants of Participation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables	**Participate**	**Participate**	**Participate**	**Participate**	**Participate**	**Participate**	**Participate**
Employees	0.0002**	0.0002**	0.0002**	0.0002**	0.0002**	0.0002**	0.0002**
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Export	0.0335	0.0329	0.0336	0.0336	0.0337	0.0336	0.0325
	(0.0240)	(0.0240)	(0.0240)	(0.0240)	(0.0240)	(0.0240)	(0.0241)
Foreign	−0.0435*	−0.0431*	−0.0433*	−0.0435*	−0.0437*	−0.0433*	−0.0459**
	(0.0231)	(0.0230)	(0.0231)	(0.0231)	(0.0231)	(0.0231)	(0.0231)
Age	−0.0001	−0.0001	−0.0001	−0.0001	−0.0001	−0.0001	−0.0002
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
Avoid taxes		−0.0304*					
		(0.0180)					
Informal payment			0.0099				
			(0.0333)				
Contract with government				−0.0008			
				(0.0208)			
Management time					0.0093		
					(0.0194)		
Import licence						−0.0083	
						(0.0285)	
Management structure							−0.116
							(0.0941)
Sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,922	1,922	1,922	1,922	1,922	1,922	1,922
R-squared	0.040	0.041	0.040	0.040	0.040	0.040	0.041

Source: Authors' calculations based on PROTEqIN survey.
Notes: Robust standard errors in parentheses. *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

the analysis in the previous section, we explored whether a female owner or manager adversely affected a firm's access to PDPs. Table 8.9 shows the results of these estimates.

Table 8.9 shows an interesting yet worrisome result. Firms with a female owner who makes major strategic and financial decisions participate less in PDPs. When we disaggregated the data by program, we found that the effect was a result of lower participation in innovation programs. These results are not enough to prove that there has been discrimination. However, it is important to be aware that this relationship exists and continue this line of research to determine how governments can address this problem if it is present.

Impact of Productive Development Programs

In this section, we focus on firms that received public support. To look for possible impacts of the programs, it is important to know which programs were used and the goals of the firms that used them. We concentrated on two types of PDPs—marketing

TABLE 8.9. Female Discrimination

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Variables	**All**	**All**	**Innovation**	**Marketing**	**Management**	**Financial**	**HR**	**Innovation**	**Marketing**	**Management**	**Financial**	**HR**
Female owner	−0.0309		−0.0382**	−0.0098	−0.0053	−0.0132	0.0101					
	(0.0199)		(0.0153)	(0.0146)	(0.0146)	(0.0124)	(0.0130)					
Female management		−0.0291*						−0.0295**	−0.0069	−0.0026	−0.0119	0.0045
		(0.0176)						(0.0139)	(0.0127)	(0.0128)	(0.0108)	(0.0106)
Employees	0.0002**	0.0002**	0.0002***	0.0001*	0.0001*	0.0001	0.0001	0.0002***	0.0001*	0.0001*	0.0001	0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Foreign	−0.0443**	−0.0459**	−0.0410**	−0.0123	−0.0324**	−0.0144	−0.0152	−0.0386**	−0.0149	−0.0350**	−0.0127	–0.0182
	(0.0224)	(0.0224)	(0.0171)	(0.0166)	(0.0145)	(0.0142)	(0.0138)	(0.0173)	(0.0164)	(0.0142)	(0.0144)	(0.0135)
Sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,966	1,948	1,966	1,966	1,966	1,966	1,966	1,948	1,948	1,948	1,948	1,948
R-squared	0.043	0.043	0.037	0.059	0.046	0.055	0.063	0.037	0.060	0.049	0.058	0.065

Source: Authors' calculations based on PROTEqIN survey.
Notes: Robust standard errors in parentheses. *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

TABLE 8.10. Uses of Marketing Support Programs

Variables	(1) Distribution methods	(2) Product placement	(3) Sales network	(4) Franchising	(5) Online promotion	(6) Online sales	(7) Pricing
Marketing support	0.0360 (0.0219)	−0.00186 (0.0157)	0.0325 (0.0231)	0.00721 (0.0169)	0.0623** (0.0269)	0.0155 (0.0218)	0.0302 (0.0221)
Ln(employees)	0.0274*** (0.00699)	0.0199*** (0.00543)	0.0314*** (0.00719)	0.00171 (0.00483)	0.0205*** (0.00740)	0.0139** (0.00703)	0.0169*** (0.00635)
Age	2.72e-05 (0.000347)	−4.69e-05 (0.000225)	−1.70e-05 (0.000356)	−7.05e-05 (0.000292)	7.19e-05 (0.000374)	−0.000296 (0.000327)	5.62e-05 (0.000258)
Foreign	−0.00423 (0.0163)	−0.0114 (0.0118)	−0.0131 (0.0161)	−0.0124 (0.0124)	−0.0150 (0.0182)	−0.0237 (0.0168)	0.00218 (0.0147)
Export	0.0109 (0.0153)	0.0160 (0.0117)	0.0275* (0.0158)	0.0124 (0.0130)	0.0198 (0.0176)	0.0409** (0.0174)	0.0201 (0.0143)
Sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,922	1,922	1,922	1,922	1,922	1,922	1,922
R-squared	0.135	0.132	0.164	0.078	0.106	0.059	0.101

Source: Authors' calculations based on PROTEqIN survey.
Notes: Robust standard errors in parentheses. *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

and innovation—because they make it possible to understand if firms were looking for new methods to commercialize their products or if they wanted to improve product characteristics or their production process.

First, we looked at whether being supported by a public marketing program had an effect on the probability of introducing improvements. Table 8.10 shows the results.

The results show whether different characteristics and a marketing PDP had an effect on the probability of introducing or improving distribution methods, adopting new methods of product placement in retail stores, sales networks, developing franchising, developing online promotion, developing online sales, or adopting new methods of pricing goods and services.

First, we noted that bigger firms were more likely to introduce an improvement in every element of marketing except franchising. Moreover, firms that exported were more prone to introduce improvements in sales networks and developing online sales. However, the most important result was that firms that participated in a marketing PDP used it to improve online promotion. We then concentrated on firms that received public support for innovation, analyzing its effect on different measures.[3] Table 8.11 presents the estimation results.

We identified two effects. First, we saw that bigger firms and those that exported were more likely to perceive all possible improvements as more important than smaller firms and those that did not export. This make it possible to understand why such firms were the highest spenders on innovation. Finally, we observed that firms supported on innovation saw important effects on sales and the ability to develop new goods and services or production processes.

Given that firms were asked about whether improvements they tried to implement were successful and whether they were funded for those

[3] These measures are constructed from the firms' points of view.

TABLE 8.11. Impact of Innovation Support Programs

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Goods offered	Increased sales	New customers	Quality	Reduced cost	Develop new goods or processes
Innovation support	0.0310 (0.0237)	0.0767*** (0.0292)	0.0372 (0.0263)	0.0298 (0.0284)	−0.00717 (0.0174)	0.0693** (0.0297)
Ln(employees)	0.0285*** (0.00708)	0.0427*** (0.00843)	0.0232*** (0.00766)	0.0314*** (0.00821)	0.0200*** (0.00639)	0.0342*** (0.00836)
Age	0.000248 (0.000388)	−0.000213 (0.000398)	0.000426 (0.000446)	0.000264 (0.000466)	0.000294 (0.000343)	2.34e-05 (0.000431)
Foreign	−0.0169 (0.0171)	0.0251 (0.0235)	0.0348 (0.0216)	−0.0127 (0.0225)	0.0419** (0.0188)	0.00853 (0.0230)
Export	0.0468*** (0.0180)	0.0970*** (0.0225)	0.0550*** (0.0200)	0.0648*** (0.0222)	0.0311* (0.0160)	0.0481** (0.0221)
Sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,922	1,922	1,922	1,922	1,922	1,922
R-squared	0.088	0.128	0.094	0.094	0.066	0.088

Source: Authors' calculations based on PROTEqIN survey.
Notes: Robust standard errors in parentheses. *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

improvements, we could test previous results. However, here we inquired as to whether the firm was supported with public funds for this particular goal as a treatment, which made it possible to know whether the public program helped firms to reach the goal. Table 8.12 shows the results of this estimation.

Firms were asked about reducing costs, the quality of goods and services, increasing national markets, increasing number of goods, developing

TABLE 8.12. Impact of PDPs on Success of Improvements

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	Reduce cost	Quality	National markets	Number of goods	Foreign markets	Promote exports	Innovation	Quality certification
Treatment	0.133 (0.123)	0.0255 (0.0602)	0.0856 (0.0830)	0.0963 (0.107)	−0.101 (0.0944)	−0.0915 (0.0918)	0.329*** (0.0713)	0.142* (0.0763)
Employees	0.000178 (0.000219)	0.000299** (0.000139)	0.000290* (0.000175)	0.000186 (0.000130)	7.15e-05 (0.000222)	3.73e-05 (0.000161)	−0.000102 (0.000126)	7.85e-05 (0.000168)
Sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	348	355	706	441	184	312	335	430
R-squared	0.289	0.629	0.197	0.302	0.594	0.683	0.565	0.363

Source: Authors' calculations based on PROTEqIN survey.
Notes: Robust standard errors in parentheses. *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

new foreign markets, promoting exports, supporting innovation, and obtaining quality certification. There were only two goals where the probability of success depended on public support: innovation and quality certification. Both were positively and significantly correlated.

This result is important because it demonstrates that not all programs effectively introduce improvements. However, both estimations show that public innovation programs effectively introduce improvements for firms, while other programs do not seem to have a significant impact on firm performance.

It is also important to see the effects of PDPs on several variables. It is hard to imagine that there was an immediate effect on measures such as productivity since the dataset referred to recent PDPs and performance measures. However, we were able to look at intermediate outcomes: innovation spending and training. We expected to see a higher level of innovation spending by firms participating in an innovation PDP. Following the same insight, we expected to see firms participating in a training support program being more likely to train their employees. The estimates are provided in Table 8.13.

TABLE 8.13. Impact of Innovation PDP on Intermediate Outcomes

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Variables	**Innovation spending**	**Ln(innovation spending)**	**Innovation spending**	**Ln(innovation spending)**	**Innovation spending**	**Ln(innovation spending)**	**Training**	**Training**	**Training**
Ln (employees)	7,882 (21,729)	0.212** (0.0956)	7,792 (21,729)	0.240** (0.0979)	8,162 (21,615)	0.173* (0.0960)	0.0860*** (0.0157)	0.0860*** (0.0157)	0.0898*** (0.0136)
Foreign	−40,396 (45,207)	0.00972 (0.170)	−40,362 (45,215)	0.0223 (0.169)	−41,634 (46,389)	0.0198 (0.170)	0.0481* (0.0289)	0.0481* (0.0289)	0.0818*** (0.0263)
Export	25,089 (39,080)	−0.0368 (0.163)	25,099 (39,084)	−0.0251 (0.164)	26,038 (38,836)	−0.0684 (0.163)	0.0791*** (0.0280)	0.0791*** (0.0280)	0.0615** (0.0248)
Age	−206.5 (510.9)	0.0014 (0.0021)	−178.3 (507.5)	0.0015 (0.0021)	−214.9 (508.8)	0.002 (0.0022)	0.0006 (0.0005)	0.0006 (0.00047)	0.0002 (0.0005)
Value added (ln)	88,778* (50,314)	0.627*** (0.0837)	88,592* (50,300)	0.612*** (0.0851)	88,911* (50,426)	0.647*** (0.0824)	0.0258** (0.0112)	0.0258** (0.0112)	0.0292*** (0.0097)
Public funding			−20,232 (13,995)	−0.455*** (0.173)				0.00398 (0.0277)	
Innovation support					−28,774 (39,854)	0.382** (0.168)			
Training program									0.572*** (0.0165)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,825	352	1,825	352	1,825	352	1,838	1,838	1,838
R-squared	0.061	0.668	0.061	0.676	0.061	0.672	0.170	0.170	0.392

Source: Authors' calculations based on PROTEqIN survey.
Notes: Robust standard errors in parentheses. *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

Since many firms in the Caribbean spend nothing on innovation, we had a truncated data problem. So, we completed two estimations: one with the entire sample and the other with the subset of firms that invested in innovation (using a logarithm). What we found was that there was no effect when using the entire sample, but a positive and significant effect on the number of employees and the value added when we restricted the sample to firms that spent on innovation. So bigger firms and those with a higher value added invested more in innovation. The same is true for innovation programs. Firms that participated in an innovation PDP spent more on innovation.

The variable public funding refers to whether access to public funding is an obstacle or not (it takes the value 1 if it is not an obstacle). The negative sign associated with this variable may indicate that firms financed their most profitable projects with their own liquidity, but that they looked for external financing when they wanted to expand to other, less profitable projects and faced an obstacle to accessing public funds.

We also noted that larger firms, foreign firms, exporters, and firms that generated a higher value added were more likely to train their employees. However, the interesting result here was that, with public support for training, firms were more likely to develop training programs.

Why is it important to invest in innovation and employee training? There is a substantial body of literature that proves that firms benefit from a number of different mechanisms. One is productivity. Firms that invest more in innovation generally have higher levels of productivity. Moreover, firms that train their employees are more likely to have higher labor productivity. We looked for these relationships in the dataset. Table 8.14 reports the results.

TABLE 8.14. Impact of Training and Innovation Spending on Productivity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Variables	**TFP1**	**TFP1**	**TFP2**	**TFP2**	**TFP3**	**TFP3**	**Value added per employee (ln)**	**Value added per employee (ln)**	**Sales per employee (ln)**	**Sales per employee (ln)**
Ln(employees)	0.0368***	0.0322***	−0.155***	−0.145***	0.0430***	0.0388***	0.0898***	0.0829***	0.109***	0.0995***
	(0.00997)	(0.00970)	(0.0333)	(0.0333)	(0.0104)	(0.0103)	(0.0217)	(0.0208)	(0.0221)	(0.0210)
Foreign	0.0671**	0.0741**	−0.0983	−0.0941	0.0668**	0.0721**	0.141**	0.153**	0.122*	0.135**
	(0.0291)	(0.0292)	(0.0947)	(0.0953)	(0.0303)	(0.0305)	(0.0654)	(0.0657)	(0.0637)	(0.0638)
Export	0.0488*	0.0501*	−0.0486	−0.0393	0.0394	0.0392	0.127**	0.131**	0.149**	0.152***
	(0.0261)	(0.0259)	(0.0928)	(0.0927)	(0.0279)	(0.0278)	(0.0591)	(0.0586)	(0.0583)	(0.0578)
Training	0.034		0.0376		0.0166		0.107**		0.105**	
	(0.0210)		(0.0703)		(0.0231)		(0.0462)		(0.0454)	
Innovation spending		6.39e-08***		−9.88e-08		4.54e-08***		1.55e-07***		2.01e-07***
		(1.59e-08)		(6.27e-08)		(1.47e-08)		(2.89e-08)		(6.61e-08)
Sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,843	1,831	1,843	1,831	1,843	1,831	1,879	1,866	1,891	1,877
R-squared	0.346	0.351	0.242	0.244	0.716	0.718	0.194	0.201	0.178	0.195

Source: Authors' calculations based on PROTEqIN survey.
Notes: Robust standard errors in parentheses. *Coefficient is statistically significant at the 10 percent level; ** at the 5 percent level; *** at the 1 percent level.

Table 8.14 shows the effects of innovation spending and training programs on several measures of productivity (3 TFP estimates and 2 labor productivity measures). The results are clear and robust for every measure, except TFP2.

First, we found that productivity was correlated with some firm characteristics. Particularly, larger firms, exporters, and foreign firms were significantly more productive. That result was to be expected because there may be economies of scale, more productive firms are more likely to export, and foreign firms are only likely to come to the Caribbean if they are likely to be among the most productive firms in the region.

The crucial point is that firms that spent more on innovation were more productive. This is key because it highlights the importance of innovation expenditures and why governments need to promote innovation. Regarding training, though there was no a significant effect on TFP, it was positively and significantly correlated with measures of labor productivity.

Conclusions

This chapter contributes to understanding participation of Caribbean firms in PDPs and its possible effects on several performance measures. We also described non-participant firms and their interests. We suggest that firms that do not participate in PDPs and are not interested in such programs could be ignoring the possible advantages that they would receive if they participated.

Looking for determinants of program participation, we found that larger firms and national firms were more likely to participate in PDPs. Moreover, we found that those firms that admitted to having avoided taxes participated less in such programs. We also found that firms with a female owner were less likely to participate in an innovation PDP. This effect was more significant if the female owner made major strategic and financial decisions, which suggests possible gender discrimination.

Among participant firms, those that participated in an innovation program were more productive, larger, and spent more on innovation. From the firm point of view, participating in this kind of program produced important effects, increasing sales and developing new goods/services or processes. We tested several possible improvements and which ones are more likely, with public support, to be successful. We only obtained a positive and significant result for innovation and obtaining a quality certification.

We also found that firms that participated in an innovation support program invested more in innovation—an intermediate outcome. Training PDPs generated a higher probability of a firm training its employees. Finally, we found that firms' investments in innovation and training had direct effects on productivity.

References

Acevedo, G. L., and H. W. Tan (Eds). 2011. "Impact Evaluation of Small and Medium Enterprise Programs in Latin America and the Caribbean." Washington, DC: The World Bank.

Agosin, M. R. 2013. "Productive Development Policies in Latin America: Past and Present." Working Paper No. 382. Santiago: Department of Economics, University of Chile.

Benavente, J. M., G. Crespi, L. Figal Garone, and A. Maffioli. 2012. "The Impact of National Research Funds: A Regression Discontinuity Approach to the Chilean FONDECYT." *Research Policy* 41(8):1461–75.

Benavente, J. M., G. Crespi, and A. Maffioli. 2007. "Public Support to Firm-Level Innovation: An Evaluation of the FONTEC Program." Working Paper No. OVE/WP-05/07. Washington, DC: Inter-American Development Bank.

Castillo, V., L. Figal Garone, A. Maffioli, S. Rojo, and R. Stucchi, R. . 2016. "The Effects of Knowledge Spillovers through Labor Mobility." MPRA Paper No. 69141.

Castillo, V., L. Figal Garone, A. Maffioli, and L. Salazar. 2015. "Tourism Policy: A Big Push to Employment? Evidence from a Multiple Synthetic Control Approach." IDB Working Paper Series No. 572. Washington DC: Inter-American Development Bank.

Crespi, G., L. Figal Garone, A. Maffioli, and M. Meléndez. 2015. "Long-term Productivity Effects of Public Support to Innovation in Colombia." *Emerging Markets Finance and Trade* 51(1):48–64.

Figal Garone, L., and A. Maffioli. 2016. "Impact Evaluation of Cluster Development Programs: An Application to the Arranjos Produtivos Locais Policy in Brazil." In A. Maffioli, C. Pietrobelli, and R. Stucchi (eds.), *The Impact Evaluation of Cluster Development Programs: Methods and Practices*. Washington DC: Inter-American Development Bank.

Figal Garone, L., A. Maffioli, J. A. De Negri, C. Rodriguez, and G. Vázquez Baré. 2014. "Cluster Development Policy, SME's Performance, and Spillovers: Evidence from Brazil." *Small Business Economics* 44(4): 925–48.

Griffith, R., S. Redding, and J. Van Reenen. 2004. "Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Industries." *Review of Economics and Statistics* 86(4):883–95.

Hall, B. H., and A. Maffioli. 2008. "Evaluating the Impact of Technology Development Funds in Emerging Economies: Evidence from Latin America." *The European Journal of Development Research* 20(2):172–98.

IDB (Inter-American Development Bank). 2014. "Rethinking Productive Development, Sounds Policies and Institutions for Economic Transition." Washington, DC: Inter-American Development Bank.

López-Acevedo, G., and M. Tinajero. 2010. "Mexico: Impact Evaluation of SME Programs Using Panel Firm Data." World Bank Policy Research Working Paper Series. Washington, DC: The World Bank.

Melo, A., and A. Rodríguez-Clare. 2006. "Productive Development Policies and Supporting Institutions in Latin America and the Caribbean: The State of State Reform in Latin America." Competitiveness Studies Series Working Paper C-106. Washington, DC: Inter-American Development Bank.

Solow, R. 1956. "A Contribution to the Theory of Economic Growth." *The Quarterly Journal of Economics* 70(1):65–94.

World Bank. 2014. "Measuring Firm Performance in Latin America and the Caribbean." Latin America and Caribbean Series Note 2. Washington, DC: The World Bank.

9

Conclusions and Policy Discussion

Sylvia Dohnert, Alessandro Maffioli, and Gustavo Crespi

Economists, policymakers, and private sector representatives have long been aware of the competitive weaknesses of the productive sector in the Caribbean. The region has been getting poorer over recent decades as its economy has stagnated due to weak economic growth and high fiscal deficits. It is widely known that economic growth is influenced by the productivity of an economy. In the Caribbean, very high debt to GDP levels, scant economies of scale, weak diversification, high vulnerability to trade shocks, and weak overall competitiveness—partly due to high labor, financing, and energy costs, but also to weak institutions and a complex business climate—have induced low productivity levels.

Against this backdrop, the private sector is called upon to be the region's motor for growth since productivity starts at the firm level and is related to the efficiency with which firms convert inputs into outputs. Around the world, the recognized importance of productivity to economic growth and the discovery of micro-level productivity differences among firms have shaped several research agendas that seek to understand what influences varying productivity outcomes at the firm level. Therefore, in recent years a vast economic literature that exploits micro-data at the firm level has developed that tries to determine the main factors (e.g., competition, innovation, human capital, and organizational forms) that induce higher levels of productivity in firms, as relocation of economic activity from lower toward higher productivity firms explains aggregate economic growth (Foster, Haltiwanger, and Krizan, 2001).

An analysis of the determinants of the productivity of Caribbean firms would help inform policymakers about mechanisms to jump-start private sector-driven growth in the region, especially since the Caribbean is characterized by small, inward-looking, and unsophisticated firms (Ruprah, Melgarejo, and Sierra, 2014). Up to now the lack of micro-level information has limited the possibility of identifying the main factors contributing to the region's low level of innovation and productivity. For many years, the Caribbean did not have internationally comparable, statistically relevant data at the firm level to perform empirical analysis of what drives firm performance and innovation. The datasets from the World Bank Latin American and Caribbean Enterprise Survey (LACES) and the follow-up Productivity, Technology, and Innovation (PROTEqIN) survey, both funded by the Compete Caribbean Program,[1] offer the first opportunity to systematically and rigorously test key hypotheses and shed some light on limiting factors. LACES and

[1] Compete Caribbean is a private sector development program funded by the IDB, the UK's Department of International Development, and the Government of Canada. In the Eastern Caribbean countries, Compete Caribbean is executed in partnership with the Caribbean Development Bank.

PROTEqIN are two powerful datasets that provide an in-depth picture of firm-level behavior related to sales, supplies, foreign trade and competition, innovation, conflict resolution, crime prevention, business environment and government relations, labor and skills, financing, and performance, among others.

Even though each chapter herein has focused on a different topic, this first round of studies sheds light on important, cross-cutting issues found to be affecting productivity in the Caribbean. These important cross-cutting factors are: access to finance, human capital, business climate and regulatory issues, and infrastructure. The following sections will explain the book's contribution to a better understanding of each of these factors.

Access to Finance

The global literature has documented a clear link between innovation and financial sector development and, by extension, economic growth at the macroeconomic level.[2] Productivity, and subsequently growth, is restricted when access to finance is constrained. Prior research indicates that in the Caribbean access to finance is difficult and affects firm performance. More firms in the Caribbean experience constrained access to finance than firms in comparable small countries (Ruprah et al., 2014). Moreover, across the region, access to finance is cited by business managers as one of the top three constraints to firm growth (Dohnert, Persaud, Pereira et al., 2016). Access to finance constraints negatively affect productivity, as Caribbean firms in the highest productivity quintiles that reported access to finance as their biggest obstacle underperformed firms in the same quintile who did not report this barrier as their biggest obstacle (Cathles and Pangerl, 2016).

This publication goes further into the nuances of how access to finance impacts firm performance by providing evidence that access to finance is a recurring constraint on innovation in the Caribbean, and that it particularly affects female managed firms. In Chapter 3, Morris found that, in the Caribbean, constrained access to finance and innovation were negatively related and that financial constraints are a major barrier to innovation regardless of geographic location and idiosyncrasy.[3] Given that in Chapter 2, Mohan, Strobl, and Watson found that cost barriers were the major barrier to innovation in the Caribbean, it is very likely that, similar to advanced countries, financial constraints are highly complementary to other impediments to innovation, such as perceived risk and innovation costs (Mohnen and Roller, 2005). Moreover, in Chapter 6, Moore, Presbitero, and Rabellotti found that there was a gender gap related to access to finance in the region, as women owned or managed firms were less likely to demand credit and more likely to report access to finance as a severe obstacle to growth. These authors also found that a gender gap in access to credit particularly affected the performance of female-managed firms. Interestingly, for all firms, in Chapter 3, Morris found that financial constraints in the Caribbean seemed to negatively affect process innovation more than product innovation.

Since overall credit constraints retard innovation, policy options that increase access to credit to the private sector should have spillover effects on innovation. In terms of debt financing, several policy options could be appropriate for the Caribbean. Given that loans in the region require collateral with fixed assets, policies that help reduce the risk profile and allow the use of moveable assets (including patents, designs, copyrights, and other forms of intellectual property) could have a positive impact on credit. In this regard, in 2014, Jamaica pioneered by implementing the first secured transactions' framework and collateral registry in the region. Moreover, access to debt financing can be influenced by bankruptcy legislation—an important area of reform in the Caribbean, where overall,

[2] See Baumol (2002) and Aghion and Durlauf (2014), which illustrate the importance of innovation for growth and development.

[3] Results from the third Eurostat Community Innovation Survey (CIS) indicate that in Europe financial constraints are the second greatest obstacle to innovation (Savignac, 2008).

resolving insolvency is a lengthy and costly process (Dohnert et al., 2016). Other forms of public policy that can help innovative firms with debt financing involve guaranteeing credit (Barbados recently launched a credit guarantee program), long-term loans, providing credit mediation,[4] supporting alternative debt financing (e.g., convertible loans), and promoting competition within the banking sector.

Policies that foster alternative mechanisms of financing, such as peer-to-peer lending and crowdfunding, could also create new sources of credit for innovative firms. In particular, equity could be an attractive alternative way to finance innovation. Some studies have identified equity as much more concerned with the overall value of the business model than with collateral when evaluating projects (Savignac, 2008). Inroads have been made to stimulate angel capital groups in the region, with some clubs having already formalized and funded ventures.[5] Finally, policies aimed at promoting firm growth and access to finance for businesses managed by women are likely to be the most effective at narrowing the gender productivity gap.

Although improving the functioning of capital markets with the measures described above would help private sector development as a whole, for projects that are highly innovative, other mechanisms of support are needed. As Navarro, Benavente, and Crespi (2016) demonstrated, innovation is wrought with market failures because it has elements of public good (new knowledge being produced, workers being trained), asymmetric information (unwillingness to share information, difficulty of accurately measuring future income streams), and coordination failures (need for firms to engage with other actors to produce innovation) that warrant a very specific type of policy response.

In Organisation for Economic Co-operation and Development (OECD) countries, these market failures are widely recognized (as is the impact of innovation on productivity and growth) and specific instruments have been designed to overcome them. Consequently, these countries have long-standing, direct transfer and tax credit public support programs that help individual firms mitigate the risk of innovation. In any given year, between 10 and 45 percent of manufacturing firms in the OECD receive support (Navarro et al., 2016). In contrast, in Latin America and the Caribbean, only 3.8 percent of all firms receive public support for innovation (Grazzi, Pietrobelli, and Szirmai, 2016), a number that declines to 2.7 percent of firms if only the Caribbean is considered (PROTEqIN). Interestingly, despite this scant supply of public support services for innovation, nearly 30 percent of firms in the Caribbean report an interest in technical assistance for technology and innovation, compared to 5 percent of firms interested in support for human resources (PROTEqIN), as shown in Figure 9.1.

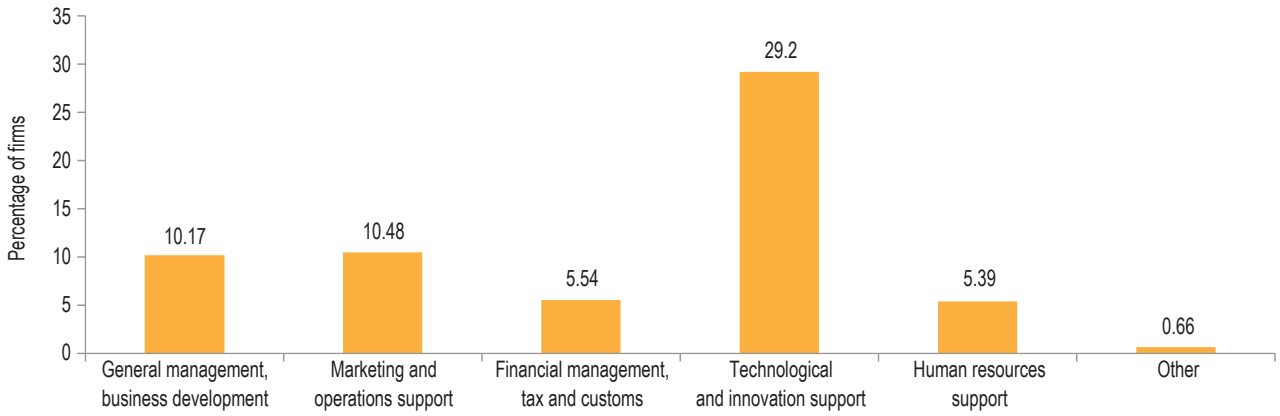
Unfortunately, there are very few instances of programs in the Caribbean that fund innovation specifically as opposed to other types of business support programs that assist firms with marketing, operations, quality compliance, and other challenges. The better known programs that specifically fund innovation in the region are as follows:

- Compete Caribbean Program: Funds innovative projects implemented by individual firms or groups of firms across the 15 CARIFORUM countries.
- Entrepreneurship Program of Innovation in the Caribbean (EPIC): Stimulates alternate financing mechanisms for innovation, such as creating angel investing groups.

[4] Credit mediation involves appointing mediators to help small and medium enterprises (SMEs) deal with loan rejections. By assisting in the loan application process, credit mediators bridge the information gap between entrepreneurs and loan officers. This type of activity could be helpful in the Caribbean. The PROTEqIN data shows that, on average, only 18 percent of firms applying for loans in the region are successful, and that 26 percent of loan rejections are due to incomplete loan applications (Dohnert et al., 2016). Credit mediation is the main role played by Small Business Development Centers in the United States, which prepare SMEs to become creditworthy.

[5] Trident Angels was formed in Barbados and First Angels in Jamaica.

FIGURE 9.1. Caribbean Firms Expressing Demand for Business Development Services



Source: Authors' calculations based on PROTEqIN.

- Caribbean Export's Regional Angel Investor Network (RAIN): Boosts the capacity of SMEs to access funding from angel investors.
- Idea to Innovation (i2i) in Trinidad and Tobago: Provides risk capital for early stage and potential high-growth companies.
- Innovation Grant from New Ideas to Entrepreneurship (IGNITE) in Jamaica: Provides grant funding to implement new ideas in new firms.
- Productivity and Competitiveness (PROCOM) challenge: Launched by the government of Saint Lucia to co-finance private sector solutions to enhance process and incremental innovation.

These instruments are all demand-based, direct subsidy programs. This is a positive feature, as research on direct subsidy programs indicates that they are effective, have a positive impact on the innovation intensity of the firms involved and on their performance, and are fiscally rewarding (Hall and Maffioli, 2008; López, 2009; Crespi, Maffioli, and Meléndez, 2011; Rivas, 2010). Moreover, these programs tend to have spillover effects on non-beneficiary firms (Castillo, Maffioli, Rojo et al., 2014). However, three of the five funding initiatives identified above are donor funded, which raises questions about the sustainability of such activities over time, and the overall quantum of funding that is being channeled toward innovation in the region. The Caribbean has had other instances of schemes to fund innovation that have not been sustained over time due to changes in government priorities and/or weak implementation. It is important to recall that one of the findings herein is that the absence of direct public funding was considered to be the most important barrier to innovation for surveyed firms (43 percent of innovators and 54 percent of potential innovators) and that a firm facing cost obstacles was 46 percent less likely to introduce a product or process innovation (Chapter 2). Therefore, it is very clear that, in the absence of well-run, dynamically consistent, and relatively sizeable programs, innovation will not pick up at the pace required to help the region resume growth.

Human Capital

This publication shows that the lack of adequately skilled human capital and the high level of informality, as well as some gender-related issues, play a crucial role in hampering innovation and productivity. Improved human capital would lead to increased capacity to absorb new technologies and practices, including those brought to the region by foreign investors.

Labor Force Skills

Policymakers in the Caribbean are preoccupied with being able to educate and retain human capital adequate for development. This preoccupation encompasses the quality of educational curriculum and their coverage, including the ability to offer vocational training and tertiary-level training, particularly in the very small countries of the Eastern Caribbean. Their worries are well founded. Nearly one-third (29 percent) of firms in the Caribbean surveyed for PROTEqIN cited an inadequately educated labor force as a major or very severe obstacle to their business operations (Dohnert et al., 2016).

Studies on innovation around the world have found that an inadequately skilled labor force is an important external barrier to innovation. In Chapter 2, Mohan et al. found that inadequate labor force skills contributed to a knowledge barrier that in turn was cited as a severe barrier to innovation, second to funding opportunities, by both innovating firms and potentially innovating firms. In particular, inadequately skilled employees, among other knowledge barriers such as technical uncertainties and lack of collaboration with knowledge brokers, reduced the probability of a product or process innovation by reducing the firm's ability to discover, incorporate, and benefit from new knowledge. For his part, in Chapter 3, Morris found that increasing the proportion of skilled workers increased the likelihood that a firm in the Caribbean would innovate and that managerial experience positively influenced the likelihood of process innovation, albeit marginally. In this regard, policies that stimulate on-the-job training and skills upgrading may be very beneficial to firms in the region that are considering innovating.

In terms of general policy prescriptions, in OECD countries much has been written about the kinds of attributes that educational systems would ideally have to foster for innovation in the workforce. These attributes concern disciplines in three skill categories: technical, thinking and creativity, and behavioral and social. Beyond specific disciplines, the method of teaching used to develop competency matters. Active teaching methods such as problem-based learning, cooperative learning, metacognitive learning, and new approaches to focusing on innovation such as design thinking are promising ways to foster innovation. Further, assessment instruments that can measure creativity and other mind habits, rather than mere knowledge, are important for a skills-for-innovation curriculum. Finally, international mobility of students, faculty, programs, and institutions is a major trend in higher education and an important way to expose students to new ideas while internalizing tacit knowledge (OECD, 2012).

Informality

Another aspect indirectly related to human capital is the significant presence of informal firms in the Caribbean and the impact informality has on the innovative behavior of formal businesses in the economy. Although the LACES and the PROTEqIN survey did not survey informal firms, the datasets include responses to questions about the degree to which informality is an obstacle. The studies discussed in several of the chapters herein were able to explore the extent to which informality affected innovative behavior in the surveyed firms because of the inclusion of such questions in the two surveys.

Authors found that more than half of the surveyed firms (55 to 60 percent) faced competition from unregistered firms and that competition from other firms—formal or informal—increased firms' decision to innovate (Mohan et al. in Chapter 2; Ambrozio and de Sousa in Chapter 4).[6] However, Ambrozio and de Sousa go further and separate the contribution of informal competition from that of formal competition on innovative behavior. They found that the influence of both formal and informal competition on innovative behavior was an inverted-U shape. That is, innovative behavior rises at lower levels of competition but then falls

[6] Interestingly, local firms were more affected by informal competition than foreign firms (Mohan et al. in Chapter 5).

as competition gets very intense. Interestingly, Ambrozio and de Sousa also found that informal competition reached its maximum impact on innovation a little before it was considered a moderate obstacle. That is, informal competition positively affected innovative behavior below the level of moderate obstacle but reduced innovation expenditure when it became very severe. On the other hand, formal competition was also found to stimulate innovation in an inverted-U. In particular, Ambrozio and de Sousa found that the level of formal competition in the region was on average below the maximum. Therefore, they recommended reducing informality to increase competition in the formal market, which should lead to increased innovation rates.

To reduce informality, some countries have experimented with reducing the costs of registration while increasing the benefits from registration (i.e., improving access of micro-enterprises to formal loans, providing formal firms with business support services, or enabling SMEs to participate in public procurement), as well as increasing the availability of information about the benefits of formalizing. Facilitating the dissemination of innovations and technologies that can help increase overall performance can lessen the productivity gaps between informal firms and the innovative part of the economy (Paunov, 2013) and provide incentives to formalize.

Gender Gaps

In the past decade, there has been a growing body of literature focused on gender and productivity. This literature has focused on the productivity and wage gaps of female employees and/or on the impact of female employees on the productivity and profitability of firms (see for example Pfeifer and Wagner, 2012). In this publication a different question was explored, namely if the gender of the business' leadership—in terms of ownership and management—matters for productivity.

In Chapter 6, Moore et al. found that female-owned firms were as productive as male-owned ones but that female-*managed* firms were not. They concluded that there is a gender gap in firm performance for female-managed firms, even after controlling for country and sector characteristics and for a large set of firm-level variables that drive productivity. However, the authors also found that differences in firm size, age, and access to finance across gender explained a significant part of the productivity gap of female-managed firms. Thus, policies aimed at promoting firm growth and access to finance for businesses managed by women are likely to be the most effective way to narrow the gender productivity gap.

Interestingly, in Chapter 2 on barriers to innovation, Mohan et al. found that potential innovators had the largest percentage of female managers (24 percent), followed by innovators (18 percent) and non-innovators (12 percent). This suggests that female-managed firms are especially deterred by barriers to innovation. Given a growing literature documenting a long tail of persistently badly managed firms in all countries and all sectors (see for example Dowdy and Van Reenen, 2014), more research is warranted to identify the linkages between female management, skills, organizational practices, and innovation.

In addition to the discovery of a gender productivity gap, in Chapter 8, Bernini, Figal Garone, and Maffioli showed that female-owned or -managed firms participated less in innovation programs. Thus, innovation policy should better target these firms and their specific needs, thus contributing to reducing potential gender discrimination. More research on the specific determinants of lower female participation in innovation programs would also be very helpful to improve policy design.

Business Climate and Regulatory Issues

Various chapters herein reference business climate and regulatory issues that impact productivity and innovation. Access to finance and human capital have already been discussed. Aside from these, themes like competition, time to market, compliance requirements with international standards,

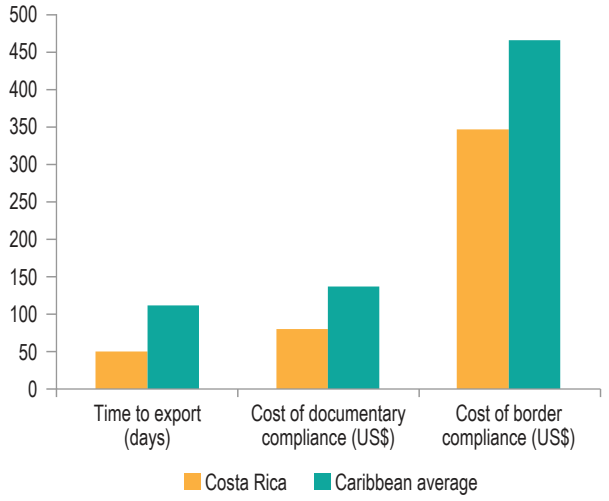
some aspects of knowledge diffusion, and intellectual property protection affect innovation in the Caribbean in important ways. In Chapter 2 on barriers to innovation, Mohan et al. indicated that innovators and potential innovators considered time to market, protection against copycats, and some knowledge-related barriers (e.g., linkages with public universities and tertiary-level institutions, flexibility and openness of laboratories and research centers to collaborative approaches, and flexibility and openness of other companies in the sector to collaborative approaches) as more important barriers to innovation than the qualifications of employees. However, these specific business climate issues had a different level of impact on the probability of innovation. While the knowledge-related barriers deterred innovation expenditure and firms with patents tended to invest more in innovation, the impact of time to market on innovation expenditure was negative and significant for innovators and potential innovators alike.

The average time to export for the 13 countries covered under the PROTEqIN dataset was 112 hours. In comparison, in a small economy like Costa Rica, which competes with the Caribbean in some industries, it took less than half as much time (50 hours) to process an export. Moreover, the cost of documentary compliance and border compliance in Costa Rica was significantly lower than in the Caribbean. In Costa Rica, documentary and border compliance amounted to only 58 percent and 74 percent, respectively, of the average cost for these transactions in the 13 Caribbean countries (The World Bank's 2016 Doing Business report and authors' calculations). These facts, along with Mohan et al.'s findings of the deterring impact of market barriers point toward the importance of government efforts to reduce the time and cost to export, especially given that Mohan et al. also found that those Caribbean firms that exported significantly increased their probability of investing in innovation.

Do policy and regulatory barriers affect local and foreign firms differently? In Chapter 5 on foreign direct investment (FDI) and innovation, Mohan et al. offered an interesting insight to this question. Similar to the overall figures for innovators and potential innovators, local and foreign firms assessed the absence of direct public funding for innovation as the most important barrier to innovative activity. As in the case of innovators and potential innovators, time to market, protection against copycats, and knowledge brokerage barriers were considered more important barriers to innovation than the qualifications of employees. Interestingly, local firms and foreign firms were not significantly different in their assessment of the importance of these constraints on innovation. The only aspect on which there was a big variation was their assessment of the importance of the flexibility and openness of laboratories and research centers to collaborative approaches. A smaller percentage of foreign firms considered this an important barrier to innovation compared to local firms (37 percent vs. 43 percent). Presumably, foreign firms have better access to in-house research and development (R&D) services.

Given that innovation is related to the acquisition, application, creation, and transmission of knowledge, with collaborative innovation becoming increasingly important, the knowledge barriers

FIGURE 9.2. Average Time and Cost of Exporting in the Caribbean vs. Costa Rica



Source: The World Bank 2016 Doing Business report.

outlined above become crucial in discussing increasing productivity and innovation in the Caribbean. Mohan et al. demonstrated that knowledge barriers had a negative and significant effect on the probability of technological innovation, reducing product and process innovation by 25 percent. In turn, policy barriers—among which protection against copycats, current organizational and managerial culture, and compliance requirements to international standards stand out as the most important—also had a negative and significant effect on the probability of technological innovation, reducing product and process innovation by 34 percent.

As expected (Table 9.1), innovators seemed to have mastered or overcome most of the barriers to innovation, expressed as lower perceptions of the importance of these barriers in comparison to potential innovators. Conversely, potential innovators stood at the other end of the spectrum and gauged these barriers as very important. Overall, surveyed local and foreign firms stood somewhere in between.

The existence of barriers to innovation and that these barriers are sorted in roughly the same order of importance by innovators and potential innovators alike and by the larger mass of firms produce consistent messages in terms of the types of policy response. An appropriate policy response to these barriers would encompass: (i) designing instruments to fund innovation; (ii) reducing the time and cost to market; (iii) promoting an effective property rights' system; and (iv) supporting mechanisms to stimulate knowledge flows between firms and universities, research centers, laboratories, and other firms.

In addition, in Chapter 8, Bernini et al. showed evidence that firms that admitted to having paid less tax participated less in productive development programs. This finding suggests that productive development policies should not be designed in isolation. Synergies and complementarities between these policies and others, such as tax and regulatory policies and even formalization efforts should be considered by policymakers to boost innovation and productivity.

Foreign Direct Investment and Knowledge Diffusion

The topic of knowledge flows warrants a specific analysis of the role of FDI, which could be considered a mechanism to finance growth and achieve technology transfer through knowledge spillovers. Historically and throughout the world, multinationals have been, on average, the most productive companies, and they have had the potential to create powerful dynamics that stimulate productivity by increasing competition and bringing technology and know-how to the host country (Dowdy and Van Reenen, 2014).

In the Caribbean, FDI has not lived up to expectations in terms of knowledge transfer. In Chapter 5 on FDI and innovation, Mohan et al. found that, consistent with the literature, foreign firms tend to be larger than domestic firms and tend to export, two characteristics that are correlated with higher innovation expenditures. Further, they found that the proportion of foreign firms that engage in innovative activity (spend on innovation, have an R&D department, cooperate on innovation, use a licensed technology, or have patents) and that have innovative outputs (product, process, market, or organizational innovation) is higher than that of local firms. However, Mohan et al. also found that the innovative efforts of foreign firms in the Caribbean did not spill over to local firms either through demonstration effects or labor mobility in the way expected from the literature. Rather, foreign technology transfer seemed to be taking place as a result of local firms importing machinery, equipment, and materials. The authors hypothesized that the distance in knowledge between foreign and local firms, and weak knowledge brokerage systems—research and development centers, and effective linkages between firms and research institutions—affected local firms' abilities to absorb and use this new knowledge.

Low spillovers from multinational subsidiaries might also be related to the kind of innovative activities that these firms implement locally. The typical local operation of a multinational enterprise (MNE)

TABLE 9.1. Barriers for Innovators and Potential Innovators, and Local and Foreign Firms

	Innovator		Potential Innovator		Local firms		Foreign firms	
Barriers	**Number**	**Percent**	**Number**	**Percent**	**Number**	**Percent**	**Number**	**Percent**
Financial/cost barriers								
Direct public funding for innovation	219	43	625	54	804	49	151	49
Level of available financial resources	209	41	526	45	714	43	126	41
Knowledge barriers								
Flexibility/openness of other companies of the sector for collaborative approaches	213	42	615	53	819	49	145	47
Flexibility/openness of laboratories /research centers for collaborative approaches	199	39	523	45	707	43	116	37
Linkages with public universities /tertiary level institutions	177	35	466	40	617	37	120	39
Qualification of employees 169	33	452	39	590	36	118	38	
Level of information on new trends of the market	155	31	455	39	599	36	113	36
Technical uncertainties	135	27	412	36	545	33	90	29
Technical capacity in key institution responsible for innovation promotion	100	20	282	24	355	21	70	23
Level of information on available technologies	98	19	286	25	371	22	68	22
Market barriers								
Time to market	195	39	583	50	749	45	138	44
Client flexibility/openness towards new goods or services	61	12	180	16	231	14	41	13
Policy/regulation barriers								
Protection against copycats	208	41	575	50	764	46	147	47
Current organizational/managerial culture	147	29	399	34	524	32	98	32
Compliance requirements to international standards	141	28	414	36	555	34	97	31
Investment/Policy framework to foster innovation	109	22	301	26	394	24	67	22
Degree of self-confidence for innovation	104	21	267	23	374	23	63	20
Internal remuneration policy and incentive structure	59	12	200	17	244	15	47	15

Source: Data drawn and sorted from two tables in Mohan et al.'s chapters herein.

is based on exploiting natural resources or accessing domestic markets using competencies built on technology developed in their home countries. In most cases, the foreign technological package is operated locally with just minor adaptations to the imported technology. In this context, demonstration effects and spillovers from labor mobility become highly restricted. Unleashing the potential of MNEs to become a source of knowledge transfer also depends on the capabilities of each national innovation system to attract higher value-added segments of each MNE's value chain (e.g., R&D labs or corporate innovation centers), which is something that requires development of local research capacities and a policy to attract FDI focused on innovation.

Competition

Competition is a very important ingredient of an effective ecosystem of innovation. Competition critically affects firms' innovation performance by providing incentives to generate new products and/or

become more effective. However, competition does not always benefit innovation. Too much competition may decrease the benefits insofar as it does not allow innovative firms to recover their investment.

As stated before, in Chapter 4, Ambrozio and de Sousa determined that, similar to developed countries, competition and innovation in the Caribbean followed an inverse-U relationship, where innovation was stimulated by competition up to a maximum, after which the impact on innovation diminished. Moreover, they found that the level of competition existing in the Caribbean had not yet reached that maximum. While these authors were not able to determine which industries were on the ascending part of the U-curve and which were on the descending part, they made some distinctions that may be useful for competition and innovation policy in the Caribbean. First, manufacturing firms spent more on innovation than service firms. Second, in the Caribbean, service firms experienced more competition than manufacturing firms. The authors concluded that increasing competition in the manufacturing sector might have a higher impact on innovation than increasing competition in services.

An innovation-focused competition policy would also need to build capacities in the local competition agencies. Improving the capacities to monitor the relationship between competition and innovation in each sector is critical, as the results suggest that this relationship is heterogeneous across sectors. This means that an across-the-board competition policy would not be optimal to encourage innovation in the different sectors. Competition authorities also need to recognize that more competition might not be good for innovation in every sector, while some practices, such as collaborative agreements among producers, which could be considered detrimental for competition overall, might be positive if collaboration is aimed at innovation and increasing competitiveness.

Infrastructure

Finally, it is widely known that electricity is one of the main inputs in manufacturing and some service-oriented firms, since all economic activities require energy. However, in the Caribbean there is empirical evidence that infrastructure gaps, particularly in the energy sector, are severely limiting productivity and innovation. Beyond the high price of energy in the region, unreliable electricity supply and unexpected outages or surges can hurt firm performance by lowering profits and outputs or damaging equipment, as has been demonstrated for other regions of the world.

Firms have different coping strategies to handle power outages, including self-generation. In Chapter 7, Barron analyzed the relationship between outages and firm behavior in the Caribbean and found that, throughout the region, increases in power outages reduced employment. Firms that had been continuously exposed to power outages reduced the size of their permanent labor force or hired fewer permanent workers. Furthermore, most of the lost jobs appeared to occur among female workers. Job shedding in the median firm amounted to roughly US$40,000 a year in lost wages. Results also suggested that increases in outages were associated with reduced likelihood of introducing innovation in goods or services, particularly for firms that resorted to self-generation as a coping mechanism. This finding suggests that firms allocate resources to self-generation that would otherwise be allocated to innovation.

These findings bear important policy implications since the likelihood of innovation and, by extension improvement in productivity levels, is clearly affected by the energy supply. Thus, governments in the Caribbean need to increase investment in energy infrastructure to reduce its deficit, therefore maintaining employment and improving the likelihood of innovation and economic activity. Further research highlighting the type of firms and sectors that are most affected by the lack of appropriate (energy) infrastructure would provide relevant insight to better target policies and improve infrastructure solutions with lasting effects on innovation and productivity in the region.

References

Aghion, P., and S. N. Durlauf, eds. 2014. *Handbook of Economic Growth*. Amsterdam, The Netherlands: Elsevier.

Baumol, W. J. 2002. *The Free Market Innovation Machine: Analyzing the Growth Miracle of Capitalism*. Princeton, NJ: Princeton University Press.

Castillo, V., A. Maffioli, S. Rojo, and R. Stucchi. 2014. "Knowledge Spillovers of Innovation Policy through Labor Mobility: An Impact Evaluation of the FONTAR Program in Argentina." Working Paper 488. Washington, DC: IDB.

Cathles, A., and S. Pangerl. 2016. "Different Obstacles for Different Productivity Levels? An Analysis of Caribbean Firms." In M. Grazzi and C. Pietrobelli, eds., *Firm Innovation and Productivity in Latin America and the Caribbean*. Washington, DC: Inter-America Development Bank (IDB).

Cole, J. R., and H. Zuckerman. 1984. "The Productivity Puzzle: Persistence and Change in Patterns of Publication of Men and Women Scientists." In P. Maehr and M. W. Steinkmap, eds., *Advances in Motivation and Achievement*, pp. 217–58. Greenwich: JAI Press.

Crespi, G., A. Maffioli, and M. Meléndez. 2011. "Public Support to Innovation: The Colombian COLCIENCIAS' Experience." Technical Note 264. Washington, DC: IDB.

Dohnert, S., T. L. Persaud, S. Pereira, W. Elliott, and K. Grant. 2016. "Toward a Business Climate Reform Agenda in the Caribbean." Discussion Paper 479. Washington, DC: IDB and Compete Caribbean. Available at http://competecaribbean.org/resources/private-sector-development/towards-business-climate-reform-agenda-caribbean/.

Dowdy, J., and J. Van Reenen. 2014. "Why Management Matters for Productivity." *McKinsey Quarterly, September*. http://www.mckinsey.com/global-themes/china/why-management-matters-for-productivity.

Foster, L., J. C. Haltiwanger, and C. J. Krizan. 2001. "Aggregate Productivity Growth: Lessons from Microeconomic Evidence." In C. R. Hulten, E. R. Dean, and M. J. Harper, eds., *New Developments in Productivity Analysis*, pp. 303–72. Cambridge, MA: National Bureau of Economic Research (NBER).

Grazzi, M., C. Pietrobelli, and A. Szirmai. 2016. "Determinants of Enterprise Performance in Latin America and the Caribbean: What Does the Micro-Evidence Tell Us?" In M. Grazzi and C. Pietrobelli, eds., *Firm Innovation and Productivity in Latin America and the Caribbean*. Washington, DC: IDB.

Hall, B. H., and A. Maffioli. 2008. "Evaluating the Impact of Technology Development Funds in Emerging Economies: Evidence from Latin America." Working Paper 13835. Cambridge, MA: NBER.

López, A. 2009. "Las evaluaciones de programas públicos de apoyo al fomento y desarrollo de la tecnología y la innovación en el sector productivo en América Latina: Una revisión crítica." Technical Note. Washington, DC: IDB.

Mohnen, P., and L.-H. Roller. 2005. "Complementarities in Innovation Policy." *European Economic Review* 49(6):1431–50.

Navarro, J. C., J. M. Benavente, and G. Crespi. 2016. "The New Imperative of Innovation Policy: Perspectives for Latin America and the Caribbean." Washington, DC: IDB.

OECD. 2012. "Better Skills, Better Jobs, Better Lives: A Strategic Approach to Skills Policies." Paris: OECD Publishing. doi: 10.1787/9789264177338-en.

Paunov, C. 2013. "Innovation and Inclusive Development: A Discussion of the Main Policy Issues." Science, Technology, and Industry Working Papers 01. Paris: OECD Publishing. http://dx.doi.org/10.1787/5k4dd1rvsnjj-en.

Pfeifer, C. and J. Wagner. 2012. "Age and Gender Composition of the Workforce, Productivity, and Profits: Evidence from a New Type of Data for German Enterprises." Discussion Paper Series 6381. Bonn: The Institute for the Study of Labor (IZA). http://ftp.iza.org/dp6381.pdf

Rivas, G. 2010. "How and When to Intervene? Criteria to Guide Interventions to Support

Productive Development." Technical Note. Washington, DC: IDB.

Ruprah, I., K. A. Melgarejo, and R. Sierra. 2014. "Is There a Caribbean Sclerosis? Stagnating Economic Growth in the Caribbean." Washington, DC: IDB.

Savignac, F. 2008. "Impact of Financial Constraints on Innovation: What Can Be Learned from a Direct Measure?" *Economics of Innovation and New Technology* 17(6):553–69.