OECD Economic Survey of Costa Rica: Research Findings on Productivity

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Editorial

OECD Economic Survey of Costa Rica: Research findings on productivity

I am delighted to introduce this book on the 'OECD Economic Survey of Costa Rica: Research Findings on Productivity'. This report complements the 2018 Economic Survey of Costa Rica. It represents a collection of studies focusing on the trends of productivity and its determinants in Costa Rica. These studies were jointly prepared by a team of experts from the OECD Secretariat and official agencies of Costa Rica and have contributed to the policy recommendations put forward by the Survey.

Costa Rica's economic and social achievements over the past 30 years have been impressive: virtually universal healthcare, primary education and pension systems have been achieved, with well-being benefits such as a sizeable middle class, low infant mortality and high life expectancy. Open trade and foreign direct investment (FDI) have been an integral part of Costa Rica's successful growth model. Strong FDI inflows have helped to make Costa Rica the location of a diversified industry that is integrated into global-value chains (GVCs). It is very encouraging that recent trends show an acceleration of productivity growth, whereas the same indicator shows a slowdown in many OECD countries; this bodes well for the future.

Despite this progress, a number of key challenges persist including, relatively high poverty, income inequality and gender gaps. In order for Costa Rica to tackle these and other structural challenges and to capitalise on the progress it has achieved thus far, it is essential to boost its productivity. This can contribute, not only towards reaching higher incomes, but also have significant positive impacts on poverty reduction, well-being and on what society delivers to citizens.

Research on productivity has demonstrated the need to go beyond the aggregates and look into firm-level data in order to provide deeper insights into the underlying drivers of productivity patterns. This book provides help to move in that direction.

This analysis makes use of international trade data to identify the products where Costa Rica's exports perform particularly well and opportunities are highlighted in order to make better use of comparative advantages to upscale production activities. The research specifically identifies two groups of products where Costa Rica's exports are performing well: a group of low-complexity products - notably agricultural products, such as pineapples, banana and coffee; and a group of high-complexity products that are technology-intensive, such as medical instruments and applications, and electrical goods. Enterprise microdata is also used to examine the productivity consequences of resource misallocation within industries. For example, recent research has found that the allocation of production factors – labour and capital – to highly-productive firms is a key determinant of productivity growth. The potential to realise further gains remains substantial; for example, adequate policies to facilitate the allocation of resources to productive firms could boost income levels in the future – a key message to policymakers.

This book is an important milestone in the production of the OECD's Economic Surveys, it demonstrates that the close collaboration between OECD and national government experts can deliver new research findings and help us in our efforts to design, develop and deliver better policies for better lives.

Angel Gurría

OECD Secretary-General

Chapter 1. Setting the scene: An overview of Costa Rica's productivity performance

Octavio Escobar and Lisa Meehan

This chapter sets the scene by providing an overview of Costa Rica's productivity performance. After historically sluggish productivity growth, Costa Rica has been slowly converging towards OECD countries over the last decade. This acceleration has been broad based and represents a structural shift towards higher productivity growth. However, GDP per capita levels remain significantly lower than high-income countries, reflecting low levels of productivity.

While this chapter is limited to analysing aggregate- and industry-level data, the remaining chapters of this book provide greater insights into specific aspects of Costa Rica's performance, with a particular focus on the use of microdata. As international productivity research has demonstrated, this allows the analysis to go beyond the aggregates to provide deeper insights into the underlying drivers of productivity patterns.

Introduction

Productivity growth is about making better use of resources to create more value. Improvements in productivity allow a given quantity of output to be produced using fewer resources or more and better output to be produced from the same resource base. Productivity is therefore an important source of cross-country differences in per capita incomes. However, its importance extends beyond higher incomes - by delivering more for less, it also allows for improvements in education, health and social services. Moreover, it also enhances some of the non-material influences on well-being, including the time available for leisure and the quality of the environment (Conway and Meehan, 2013[1]). Overall, productivity is key to raising well-being as "nothing contributes more to the reduction of poverty, to increases in leisure, and to the country's ability to finance education, public health, environment and the arts" (Blinder and Baumol, 1993, p. 778[2])

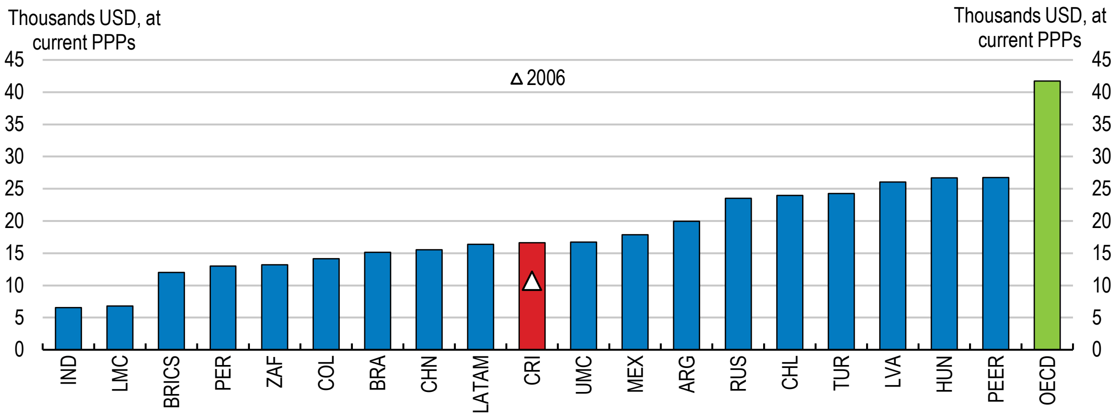
This chapter provides an overview of Costa Rica's productivity performance over time and in comparison to other countries, particularly OECD countries. The focus is on illustrating productivity trends to set the scene for the following chapters and for further discussions on how to boost Costa Rica's performance. The more in-depth analyses presented in the following chapters of this volume will provide greater insights into particular aspects of the Costa Rican economy and its productivity performance from a variety of approaches and perspectives. Chapter 2 uses firm-level data to examine spillovers from FDI by asking whether the presence of foreign firms raises the productivity of domestic firms. Chapter 3 uses detailed product-level data to identify upscale opportunities in trade. Chapter 4 uses firm microdata to examine the productivity consequences of resource misallocation within industries. These analyses provide insights for, and are complementary to, the OECD's ongoing work on how to improve Costa Rica's public policy settings in order to boost productivity and well-being. This work includes the 2018 Economic Survey of Costa Rica (OECD, 2018[3]), as well as recent in-depth reviews into structural policies relating to education (OECD, 2017[4]), science and innovation (OECD, 2017[5]), agriculture (OECD, 2017[6]), tax (OECD, 2017[7]) public sector and corporate governance (OECD, 2015[8]), healthcare (OECD, 2017[9]) and labour market policies (OECD, 2017[10]).

Overall, Costa Rica's economic and social achievements have been impressive (OECD, 2018[3]). GDP per capita has increased significantly over the last 30 years and the country has achieved upper-middle income levels according to the World Bank classification (Figure 1.1). Virtually universal healthcare, primary education and pension systems have underpinned Costa Rica's significant human development progress, with well-being benefits such as a sizeable middle class, low infant mortality and high life expectancy. Poverty, income inequality and gender gaps are remain high relative to OECD countries, albeit low by Latin American standards (OECD, 2018[3]).

Open trade and foreign direct investment have been an integral part of Costa Rica's successful growth model. Strong FDI inflows, facilitated by an educated population and a friendly FDI regime, have supported Costa Rica's structural transformation from a rural and agricultural-based economy to one with a more diversified structure that is integrated into global-value chains. This has allowed for a sustained expansion of production since the mid-1980s (Rodríguez-Clare, 2001[11]; OECD, 2018[3]). This model continued to bear fruit and during the first decade of the 21st century, and Costa Rica's average growth rate exceeded that of Central American countries and of Latin America as a whole (Beverinotti et al., 2014[12]). It also helped Costa Rica's growth to recover quickly after the global financial crisis. While GDP growth fell sharply and even turned negative in 2008-09, the recession was short-lived. Growth rebounded quickly to 5% in 2010-2012, supported by strong FDI inflows, particularly in high-tech manufacturing and knowledge-intensive services (OECD, 2017[13]; OECD, 2018[3]).

Figure 1.1. Costa Rica has achieved upper-middle income status through strong growth

GDP per capita, 2016 or latest available year



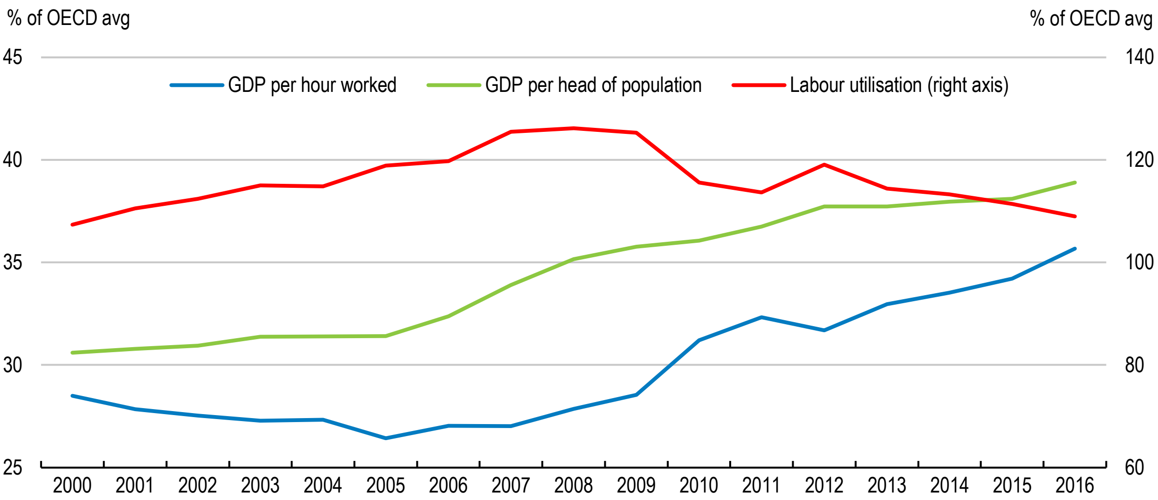
Note: PEER refers to the 10 non-Latin American OECD countries with the lowest GDP per capita: Czech Republic, Estonia, Greece, Hungary, Latvia, Poland, Portugal, Slovak Republic, Slovenia and Turkey. LMC and UMC refers to the lower-middle-income and upper-middle-income economies as classified by the World Bank. LATAM refers to Argentina, Brazil, Chile, Colombia, Costa Rica, Mexico and Peru. BRICS refers to Brazil, Russian Federation, India, China and South Africa.
Source: World Bank Development Indicators.

While the rapid expansion of skill and knowledge-intensive sectors is contributing to this robust growth, like many emerging markets, the economy retains a dual structure. Innovation and technology use is concentrated among firms in free-trade zones. These high-productivity firms co-exist with low-productivity domestic (including informal) firms. There is limited integration of local firms into the supply chains of multi-national firms due to a mismatch between what foreign firms demand and the competencies of the local business sector (OECD, 2017[5]). However, there is evidence that business relationships with foreign firms increase the productivity of domestic firms (Chapter 2). Moreover, there is an increasingly dynamic services sector, with sophisticated business services and informatics accounting for 45% of the total services sector (OECD, 2017[5]). However, Costa Rica continues to lag behind on innovation measures. Spending on research and development as a share of GDP is on par with other Latin American countries with a similar level of development, but it has stagnated in recent years and remains well below the OECD average. Costa Rica also performs well below other Latin American and OECD countries in terms of intellectual production, such as patents and industrial design (OECD, 2017[5])

Moreover, while Costa Rica's growth has been strong, significant gaps with higher income countries remain. In 2016, GDP per capita was 39% of the OECD average and remains below that of Mexico and Chile. This gap reflects low labour productivity, which stands at 36% of the OECD average (Figure 1.2), and reflects many years of sluggish growth (Monge-González, 2016). However, productivity growth has picked up in recent years. Average annual labour productivity growth has increased from 0.9% between 1992 and 2007 to 4.0% between 2007 and 2016, and similarly, multi-factor productivity (MFP) growth has gone from 1.1% to 2.5% (see Box 1.1 for a discussion of MFP and other productivity concepts). Furthermore, even at the faster growth rate of 4.0% a year, it will take more than 25 years to reach the current OECD average labour productivity level.

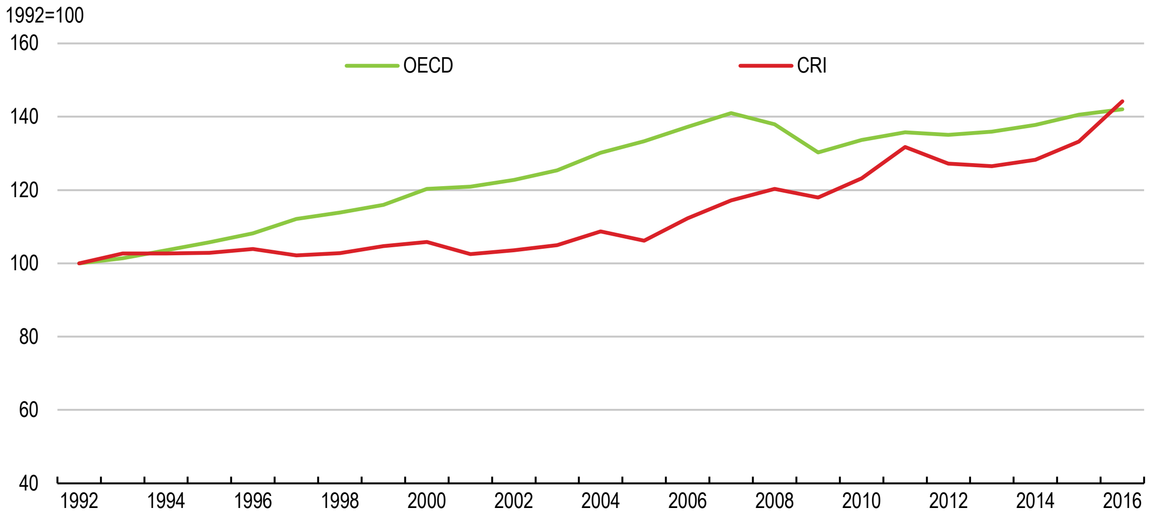
This structural and technological shift is also creating new challenges. Inequality has been increasing, which contrasts with the general trend in Latin America, and highlights that the benefits of strong growth have not been widely shared. In particular, growth has not translated into positive labour market outcomes. The unemployment rate (9.1%) remains elevated by international and historical standards. At 41%, labour market informality is low by Latin American standards, but has remained stubbornly high while it has been decreasing in other countries in the region. The education system has not kept pace with this ongoing transformation towards technological- and knowledge-intensive sectors, resulting in skill shortages and a rising skills premium despite the high levels of unemployment. Low outcomes and high inequalities in education persist despite high levels of public spending on education, which also highlights issues with public sector spending efficiency and productivity. For example, rising public spending on health and education has not translated into improved outcomes. More broadly, the fiscal stimulus implemented in the wake of the global financial crisis has not been reversed despite the strong recovery, resulting in persistent and large fiscal deficits. Public debt as a share of GDP is rising fast, and if left unaddressed, could threaten macroeconomic stability, and ultimately, Costa Rica's successful growth model. While the focus of this chapter is on the productivity performance of the Costa Rican economy, these factors provide important context, and are discussed in detail in the OECD Economic Survey (OECD, 2018[3]).

Figure 1.2. GDP per capita and labour productivity are converging but remain at low levels



Source: OECD Productivity Database.

Figure 1.3. MFP growth has picked up



Note: OECD is a simple average of the growth rates in OECD countries.
Source: OECD Analytical Database.

Box 1.1. Productivity concepts and data

Measuring productivity

GDP per capita can be decomposed into two main components: labour productivity and labour utilisation. Labour productivity can be further decomposed into capital intensity – the amount of capital per unit of labour – and multi-factor productivity (MFP).

MFP reflects the efficiency with which a combination of productive inputs is used to produce output. As such, it is often considered a proxy for broad technological advances that increase the amount of output produced for a given amount of labour and capital. This potentially includes a range of factors such as improvements in management and production processes, increased scale, skill accumulation and improvements in the effectiveness with which labour is combined with capital. However, MFP is measured as a residual, so in practice MFP reflects some combination of technological progress and any model misspecification or mismeasurement of productive inputs (Conway and Meehan, 2013[1]; OECD, 2015[14]).

To estimate MFP, a Cobb-Douglas production function is used, consistent with the approach used in the OECD Analytical database (Guillemette et al., 2017[15]).

$$\boldsymbol{Y_{it} = A_{it}K_{it}^{\alpha}L_{it}^{\beta}} \qquad \textbf{(1.1)}$$

where Y_it is the real GDP of country i in year t, A_it is MFP, K_it is the productive capital stock, and K_it is labour input. The following log-linearised function is estimated:

$$\boldsymbol{\ln(Y_{it}) = \alpha \ln(K_{it}) + \beta \ln(\mathrm{L_{it}}) + \theta_i + \mu_t + \varepsilon_{it},} \qquad \textbf{(1.2)}$$

where θ_i is the country-specific technological factor, μ_t is a time-dependent technological factor that is constant across countries, and ε_it is a country-specific and time-dependent technological factor.

Equation 1.2 is estimated using data from the OECD Analytical Database for a panel of 40 countries (all OECD countries, Costa Rica, Brazil, Colombia, Russia and South Africa) for the years 1991-2017. Consistent with the OECD's estimates, this provides α=0.34 and β=0.66.

Estimates of Equation 1.2 are then used to compute the log of MFP as:

$$\boldsymbol{\ln(MFP_{it}) = \theta_i + \mu_t + \varepsilon_{it}} \qquad \textbf{(1.3)}$$

Data

The cross-country comparisons of aggregate economy labour productivity use data from the OECD Productivity Database. For cross-country comparisons of aggregate MFP, the OECD Analytical Database is used because MFP data for

Costa Rica are not available in the Productivity Database. This choice was made to allow comparisons with the widest range of countries and time periods on a consistent basis. In particular, it is difficult to obtain a consistent measure of capital stock for all countries.[1]

There are several measurement differences between the OECD Productivity and Analytical databases. An important difference is that labour input is measured as hours worked in the Productivity Database but number of workers in the Analytical Database. Hours worked is a preferable measure since it takes account of cross-country differences in hours per worker. This matters in the case of Costa Rica where those with jobs work very long hours, but a lower share of the population works compared with the OECD average (OECD, 2018[3]) (Figure 1.4, Panel B). Therefore, by the hours worked measure, Costa Rica’s labour utilisation is higher than the OECD average (hours/population), but by the employment measure, labour utilisation (workers/population) is below average. This means that Costa Rica’s labour productivity relative to OECD countries will be overestimated if the number of workers is used instead of the total hours worked.

The country-specific analysis for Costa Rica uses data from the Central Bank of Costa Rica. Both labour productivity and MFP are estimated at the aggregate economy level. Labour productivity is also calculated for 15 industries. However, MFP estimates at the industry level are not estimated due to a lack of industry-level capital series.

It should be noted that the use of different data sources means that the labour productivity and MFP measures used here are not internally consistent, but have been chosen on the basis of their suitability for the particular task at hand.

Productivity is key to Costa Rica’s convergence to higher-income countries

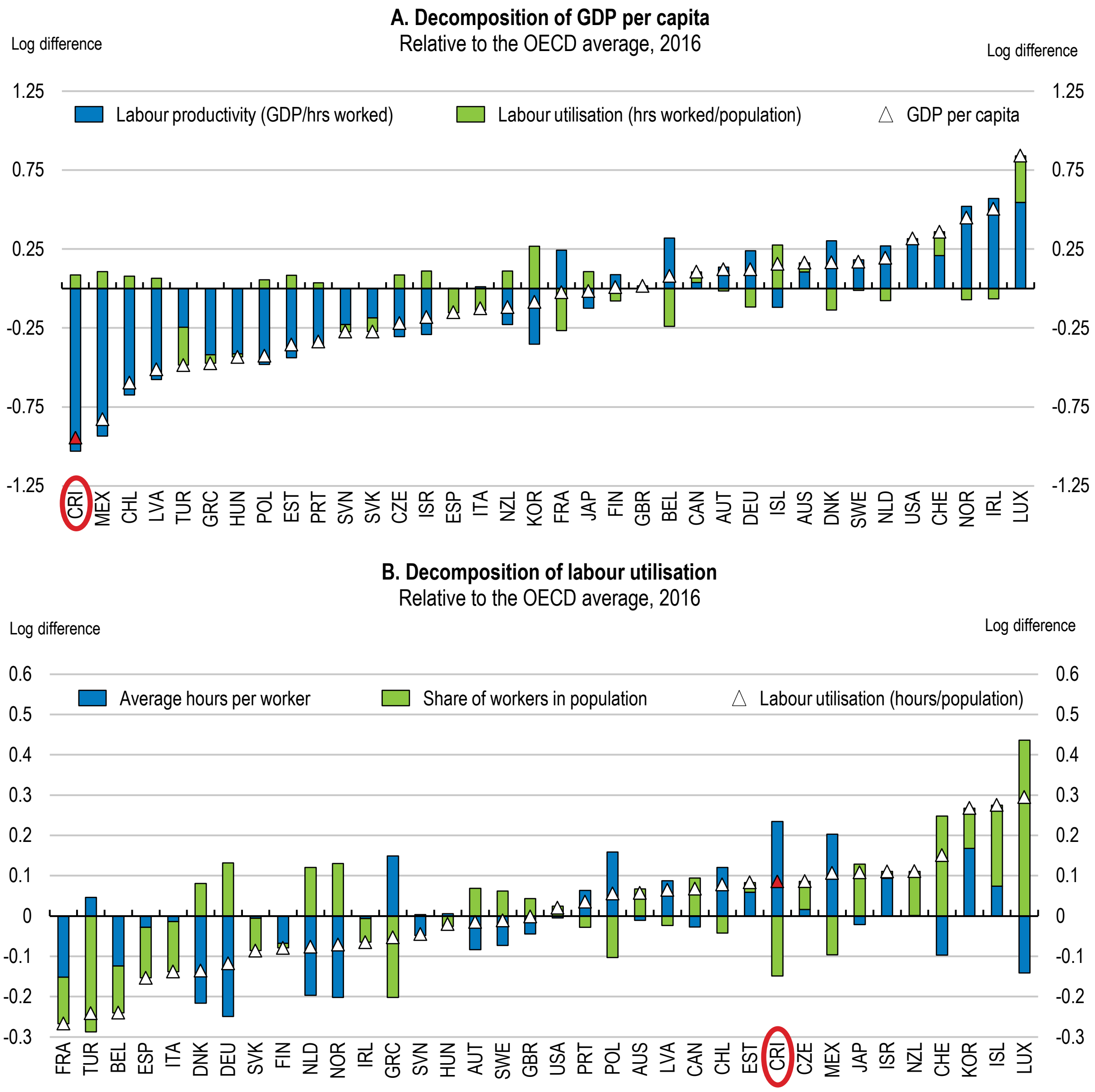
A decomposition of GDP per capita into labour productivity (GDP per hours worked) and labour utilisation (hours worked per person) reveals that labour productivity is the source of Costa Rica’s income gap with OECD countries (Figure 1.4, Panel A). In 2016, Costa Rica’s GDP per capita was about USD16,400 compared with about USD42,100 on average in OECD countries. Similarly, GDP per hour worked was about USD18.6 compared with an OECD average of USD51.9.[2] In contrast, Costa Rica’s labour utilisation is comparative high, at 109% of the OECD average. However, this has been falling from a peak of 126% in 2008. In addition, this high labour utilisation reflects above-average hours per worker, while the share of workers in the Costa Rican population is lower than all OECD countries except Turkey and Greece (Figure 1.4, Panel B). Overall, while making the Costa Rican labour market more inclusive is also a challenge and failing to address this issue will weigh on future productivity growth

[1] For example, alternative sources such as the World Bank provide data on Gross Capital Formation and estimates capital stocks. This requires a long time-series of investment volumes and price deflators, but changing methodological practices over time make it difficult to estimate for some countries (particularly emerging economies).

[2] In USD, current prices, current PPPs.

(OECD, 2016[16]; OECD, 2018[3]), it is clear that boosting productivity is key to Costa Rica’s convergence to higher-income countries.

Figure 1.4. Costa Rica's GDP per capita gap reflects low productivity



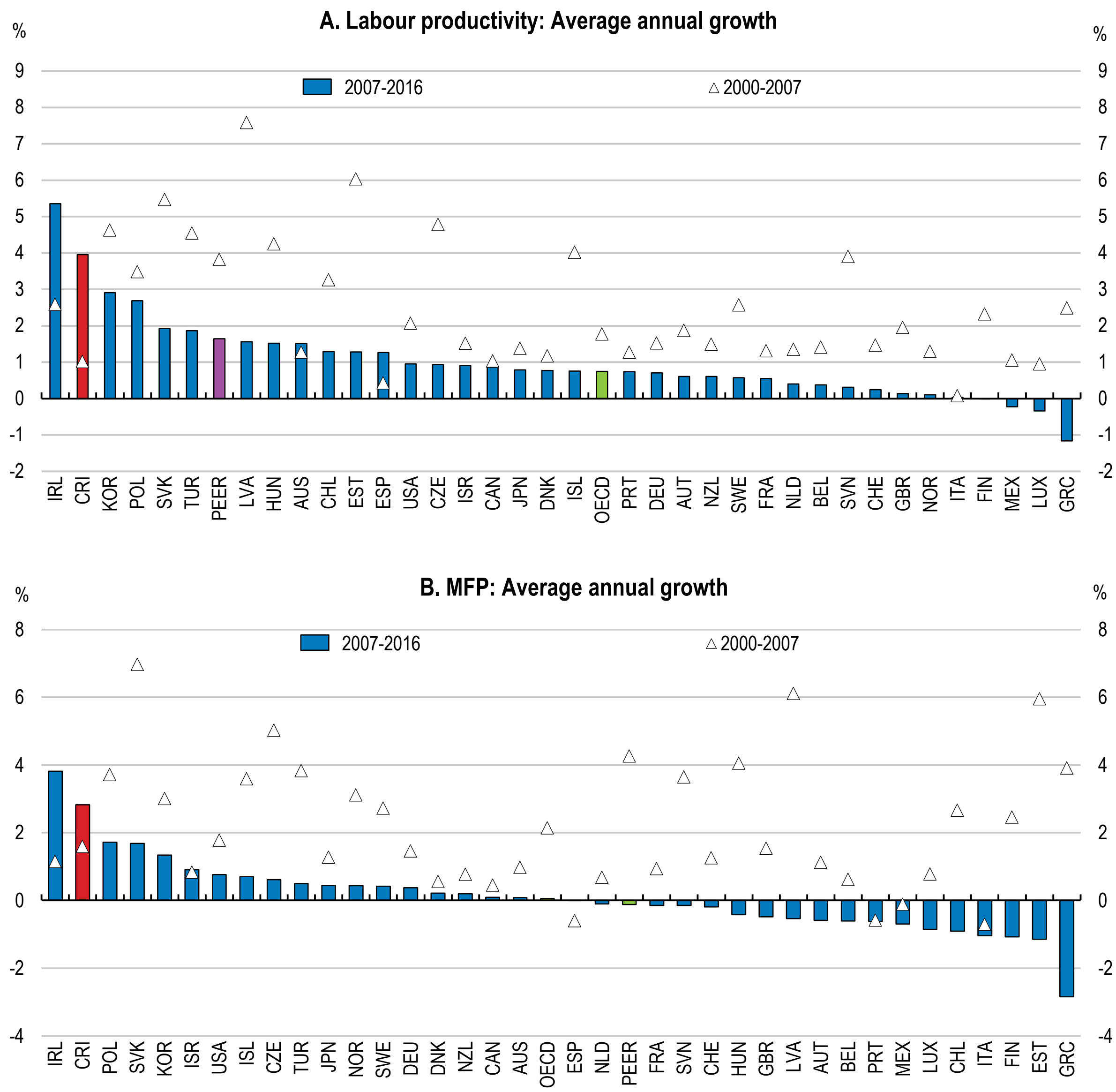
Source: OECD Productivity Database.

However, Costa Rica has been slowly closing the labour productivity gap since the mid-2000s. In the early 2000s, Costa Rica’s labour productivity growth was somewhat slower than the OECD average and well behind other catch-up countries. For example, the 10 non-Latin American OECD countries with the lowest GDP per capita[3] had labour productivity growth of 3.8% between 2000 and 2007, compared with Costa Rica’s 1.0%.

[3] Namely, the Czech Republic, Estonia, Greece, Hungary, Latvia, Poland, Portugal, the Slovak Republic, Slovenia and Turkey.

Labour productivity growth has been high relative to the OECD average in recent years – in fact, from 2007 to 2016, only Ireland has had a faster growth rate (Figure 1.5, Panel A). Also, while the vast majority of OECD countries have been experiencing a productivity slowdown, Costa Rica's labour productivity growth rate has accelerated (Figure 1.5, Panel A). Overall, Costa Rica's labour productivity performance has improved both in comparison with other countries and also over time.

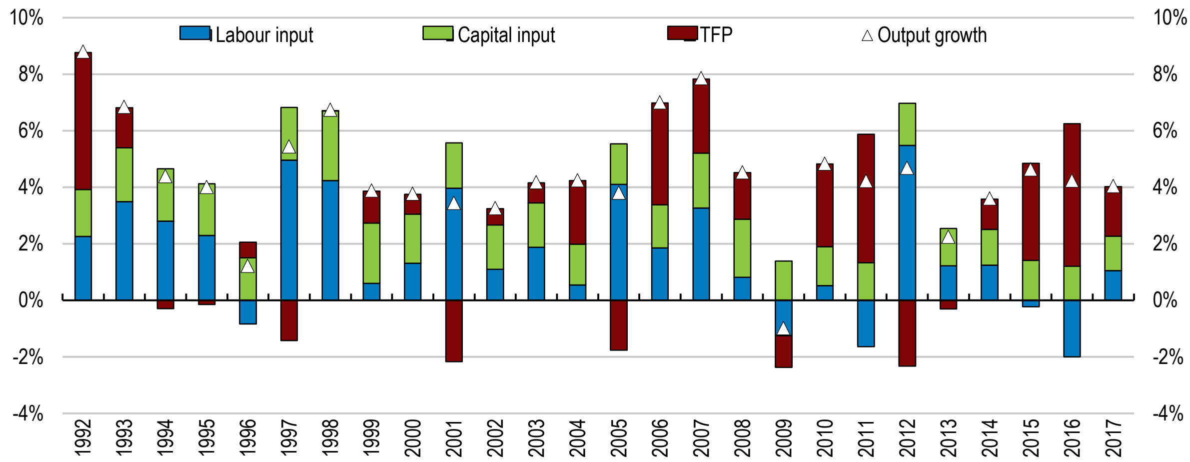
Figure 1.5. Productivity growth has been higher than most OECD countries in the last decade



Note: Panel A measures labour input as hours worked while Panel B uses total employment (see Box 1.1).
Source: OECD Productivity Database; OECD Analytical Database.

This pattern of strong growth compared with OECD countries and in comparison to earlier years is also mirrored in MFP growth (Figure 1.5, Panel B). A growth accounting decomposition of Costa Rica's output growth into contributions from increases in labour and capital inputs and MFP also confirms that the MFP growth has become more important for Costa Rica's output growth during recent years. While MFP accounted for only 15% of output growth during the 1990s, its contribution increased to an average of 50% since 2010 (Figure 1.6).

Figure 1.6. The contribution of MFP to output growth has been increasing



Source: OECD Analytical Database.

The reasons behind this acceleration in productivity growth, including possible policy drivers, are not immediately apparent. The opening of Costa Rica's economy was a significant policy reform, however it started in the 1980s and therefore occurred well before the acceleration in productivity experienced over the last decade. Some reforms have taken place since the mid-2000s which likely contributed to productivity growth over this period, such as liberalisation of the telecommunications and insurance industries, however, there was not a substantial shift. While the deeper reasons behind this acceleration require further analysis, the next sections of this chapter will provide a closer look into Costa Rica's aggregate- and industry-level productivity performance. First, the question of whether the acceleration in productivity growth represents a structural trend, and at what point there was a "break" in the series towards higher growth is explored. Then, industry labour productivity is examined to see whether the acceleration was broad based or due to faster growth in a relatively small number of industries. Finally, the role of structural change is explored in order to examine to what extent productivity growth has been driven by labour movements towards higher productivity industries versus productivity growth within industries.

The acceleration in productivity growth represents a structural trend

The widespread slowdown in productivity growth experienced in most countries over the 2000s has led to discussions about the extent to which it represents structural or cyclical factors. Part of the slowdown is likely to reflect the pro-cyclicality of MFP, whereby firms may respond to short-run fluctuations in demand by varying the rates at which capital and labour are utilised, for example, by hoarding labour during a downturn and waiting for the recover or under-utilising existing capital stock without shedding it

(OECD, 2015[14]). However, structural factors are also relevant, such as reduced availability of financing and evidence that productivity-enhancing reallocation was not as strong as in previous recessions (OECD, 2015[14]; Foster, Grim and Haltiwanger, 2016[17]).

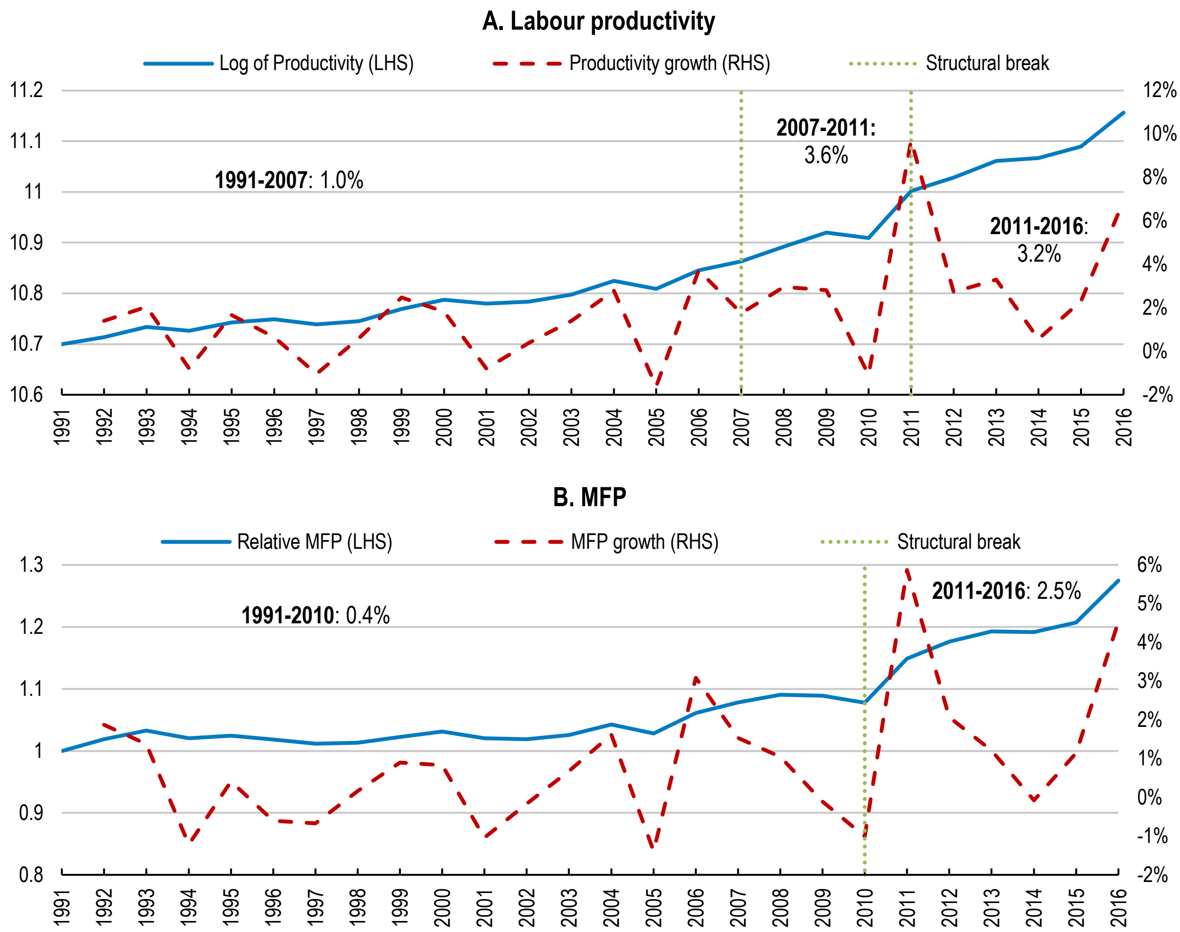
As discussed, Costa Rica has bucked this general trend, experiencing a marked increase in productivity in recent years. However, the question of whether the pick-up in growth represents a structural break is still relevant.

Analysis to identify structural breaks (see Box 1.2) suggests that the shift to higher productivity growth over the last decade reflects a positive structural break. Three distinct cycles in the labour productivity data are identified. The average annual labour productivity growth before the first break (1991-2007) was 1.0%, and it increased to 3.6% for 2007-2011, before decreasing slightly to 3.2% for 2011-2016 (Figure 1.7, Panel A). For TFP, there is only one structural break in the year 2010. The acceleration in MFP growth occurred later than the pick-up in labour productivity, with average annual MFP growth of 0.3% between 1991 and 2010 to 2.5% from 2010-2016 (Figure 1.7, Panel B).

This analysis does not, however, identify the underlying causes of this shift to higher average productivity growth. It may be that the benefits of the export-led strategy were only beginning to be fully realised after a period of adjustment and re-structuring, or other policy reforms during this period may have brought benefits. A less positive factor may be that the higher unemployment rates experienced in Costa Rica since the global financial crisis (4.6% in 2007 versus 9.1% in 2017) and falling labour force participation rates may have resulted in a compositional effect, whereby those with lower-skills were more likely to leave the work force, raising the overall skill level of workers and thereby increasing measured MFP.

Of course, the underlying causes of the faster productivity growth are not easy to identify. As an example, despite an extensive body of research on why there has been a widespread slowdown in productivity internationally, there are no easy answers to the cause of, or remedy for, the malaise. However, new research using microdata to analysis firm behaviour is providing new insights into, for example, the role of technology diffusion, investment, competition and resource allocation (OECD, 2015[14]). The Costa Rican microdata has only just began to be explored, and is likely to also provide insights into firm behaviour and, consequently, aggregate productivity performance. This prospect is an important motivation behind this volume.

Figure 1.7. Labour productivity and MFP have shifted to higher-growth paths



Note: Percentages refer to average annual growth rates over the specified period. See Box 1.2 for details of the estimation of structural breaks.
Source: Authors' calculations using Banco Central de Costa Rica data.

Box 1.2. Identifying structural breaks in productivity growth

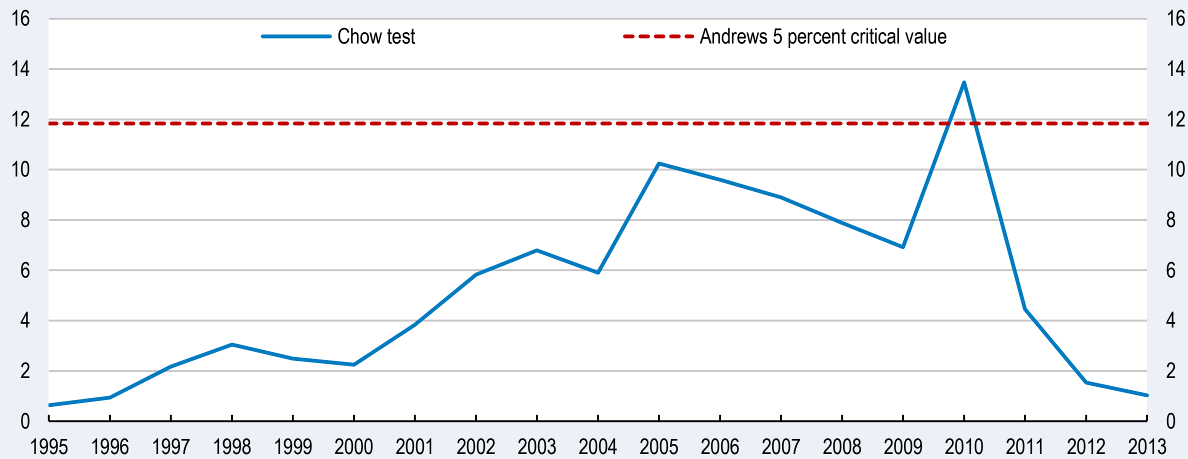
Following Hansen (2001[18]), a first-order auto-regressive model is used to identify structural breaks in Costa Rica's labour productivity:

$$\Delta \boldsymbol{LP_t} = \boldsymbol{\alpha} + \boldsymbol{\beta} \Delta \boldsymbol{LP_{t-1}} + \boldsymbol{\varepsilon_t} \qquad \textbf{(1.4)}$$

where ε_t is a time series of serially uncorrelated shocks, and α and β are the parameters to be estimated. A structural break occurs when at least one of these parameters changes in the sample period (Hansen, 2001[18]). Changes in the parameter α could be interpreted as changes in the trend, while changes in the autoregressive parameter β correspond to changes in the serial correlation in ΔLP_t.

First, the potential existence of structural breaks is investigated. Following the literature (Andrews, 1993[19]; Hansen, 2001[18]; Hansen, 2002[20]), the values of the Chow (1960[21]) statistics are estimated as a function of potential break dates. The null hypothesis of no structural break is rejected when the Chow statistics for a given date is significantly larger than those of other dates (Andrews, 1993[19]). If all the Chow statistics are below a critical value, there is no structural break. This is illustrated for the aggregate labour productivity series - the Chow test exceeds the Andrews critical value in 2010, so there is significant evidence of structural breaks (Figure 1.8).

Figure 1.8. Chow test for structural breaks in aggregate labour posting



Source: Authors' calculations using Banco Central de Costa Rica data.

To determine the number of breaks and break dates, the algorithm of Bai and Perron (2003[22]) is applied to identify multiple endogenous breaks. Illustrating with the aggregate labour productivity series, Bayesian Information Criterion (BIC) selects a model with only one breakpoint in 2010, which corresponds to the year with the highest Chow statistics in Figure 1.8. However, Bai and Perron (2003[22]) notes that the BIC is problematic in dynamic regressions. Therefore, following Bai and Perron (2003[22]), the Sup F test is then estimated. Table 1.1 shows that according to the Sup F test, there is significant evidence of the existence of breaks in the aggregate labour productivity series, and the optimum number is two breaks.

Table 1.1. Sup F test for estimating the number of structural breaks

Null of no break against the existence of a fixed number of breaks			
0 vs 1	0 vs 2	0 vs 3	0 vs 4
6.74**	6.20**	4.52**	3.36*
Null of the existence of k breaks against the alternative of k+i breaks			
2 vs 1	3 vs 2	4 vs 2	
3.79*	1.07	0.8	

Note: * significant at the 5% level. ** significant at the 1% level. The $\mathrm{SupF_T(k)}$ tests allow for serial correlation in the disturbances.
Source: Authors' calculations using Banco Central de Costa Rica data.

The model is then used to analyse whether the structural break is driven by an increase in the mean growth rate, or by changes in the autoregressive parameter. Table 1.2 presents the results for aggregate labour productivity. The results suggest a significant shift in the mean growth rate, particularly during the second period of 2007-2011.

Table 1.2. Empirical estimates with three breaks

		?/m:r>	T1	T2
1993-2007	0.013**	-0.311	2007	2011
	(0.004)	(0.247)	(2005-2008)	(2010-2013)
2007-2011	0.072**	-2.200**		
	(0.011)	(0.463)		
2011-2016	0.035*	-0.087		
	(0.014)	(0.296)		

Note: * significant at the 5% level. ** significant at the 1% level. In parentheses under the estimates robust to serial correlation standard errors, and the 95% confidence intervals for $\hat{T}_1$ and $\hat{T}_2$.
Source: Authors' calculations using Banco Central de Costa Rica data.

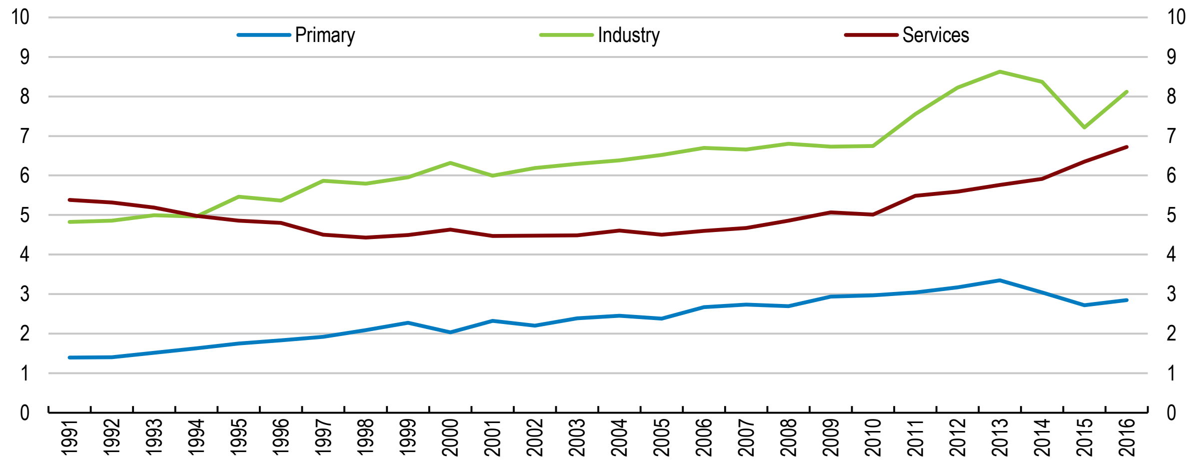
Industry performance: The acceleration in productivity growth is broad-based

A closer examination of the productivity performance of sectors and industries can add to the understanding of the aggregate productivity trends. For example, it may be that the general pick-up in productivity was driven by a few industries while others continue to lag behind.

First, looking at the overall growth patterns by broad economic sectors, in all three – primary, industry and services – labour productivity has increased over time. However, the level of productivity and its evolution differs by sector. The primary sector has relatively low productivity, but this has increased steadily over time, gradually reducing the productivity gap with the other sectors. The industrial sector has relatively high labour productivity which has been increasing over time, but with greater volatility in more recent years. The services sector exhibited a negative trend until 2005, when productivity started to growth (Figure 1.9).

Figure 1.9. Labour productivity levels and growth differ across broad sectors

Labour productivity (value added per hour worked), 2012 colones (thousands)



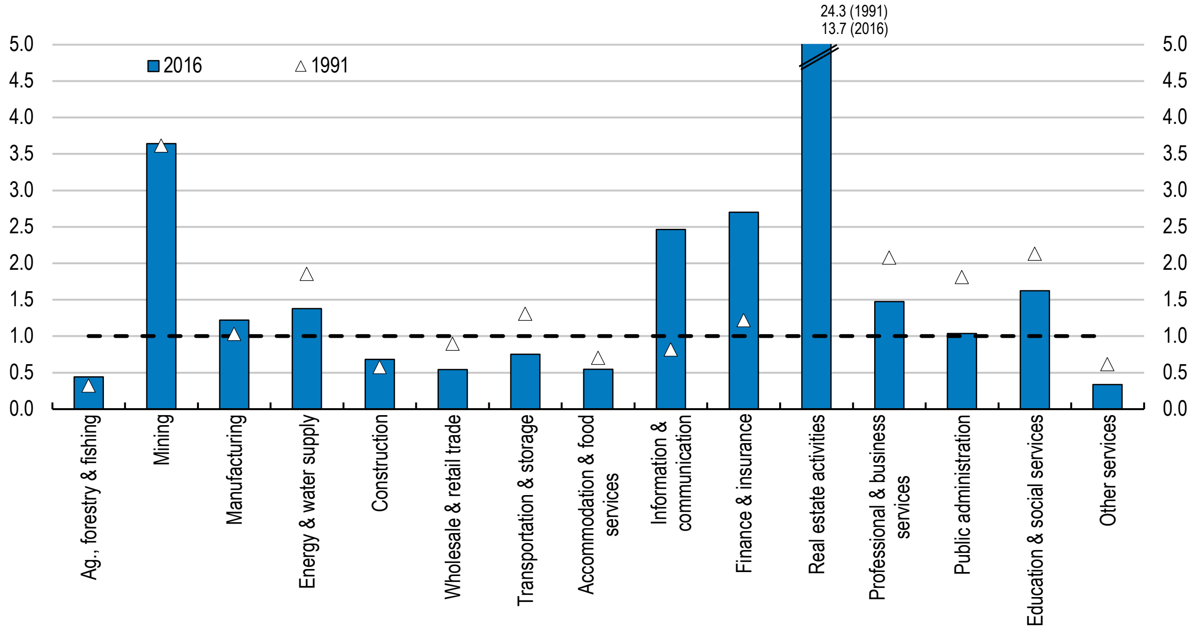
Source: Authors' calculations using Banco Central de Costa Rica data.

While this seems to suggest that the pick-up in productivity over the last decade was due to improved performance of the services sector, these broad sector trends mask differences at the industry level. In particular, the services sector not only consists of some of the lowest and highest productivity industries in terms of levels, but also has some of the industries with the strongest productivity growth, such as information & communications and financial & insurance activities, but also some that have had negative productivity growth, such as real estate activities (Figure 1.10).[4]

[4] Although it is beyond the scope of this work to investigate, part of the explanation for the very high levels of labour productivity in the real estate services industry may be due to measurement issues. As an example, part of New Zealand's high level of labour productivity in the rental, hiring and real estate services industry compared with Australia's can be partly attributed to the inclusion of the output of private rental dwellings in this industry in New Zealand, but with a lack of associated labour input. In contrast, Australia includes private rental dwellings as part of 'Ownership of dwellings' (alongside owner-occupied dwellings) (Mason, 2013[81]).

Figure 1.10. Labour productivity levels and growth differ marked across industries

Industry labour productivity levels relative to aggregate levels



Source: Authors' calculations using Banco Central de Costa Rica data.

Overall, the acceleration in labour productivity was reasonably broad based, with 12 out of the 15 industries experiencing faster growth from 2007-2016 compared with 1991-2007. Only agriculture, forestry & fishing, energy & water supply, and real estate activities experienced slower productivity growth in the 2007-2016 period compared with the 1991-2007 period.

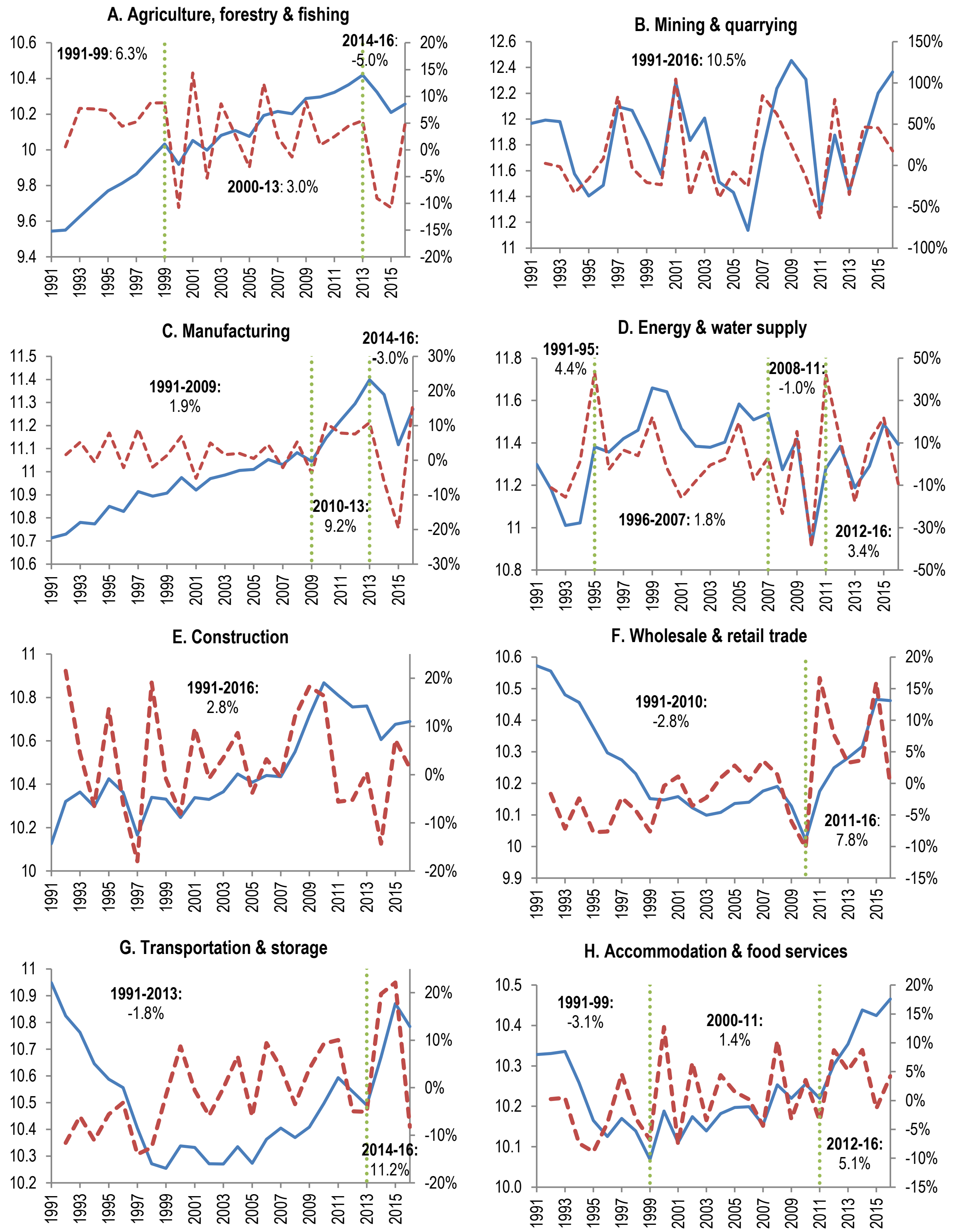
Despite the acceleration of growth being broad based, the patterns of labour productivity growth across industries varies in terms of the growth rates, when structural breaks occurred and whether these breaks were positive (with higher growth after the break) or negative (with lower growth after the break). As an example of how industry performance varied, the average annual labour productivity growth rate over the 2007-2016 period ranged from a modest 0.6% in agriculture, forestry & fishing to an impressive 24.5% in information & communication.

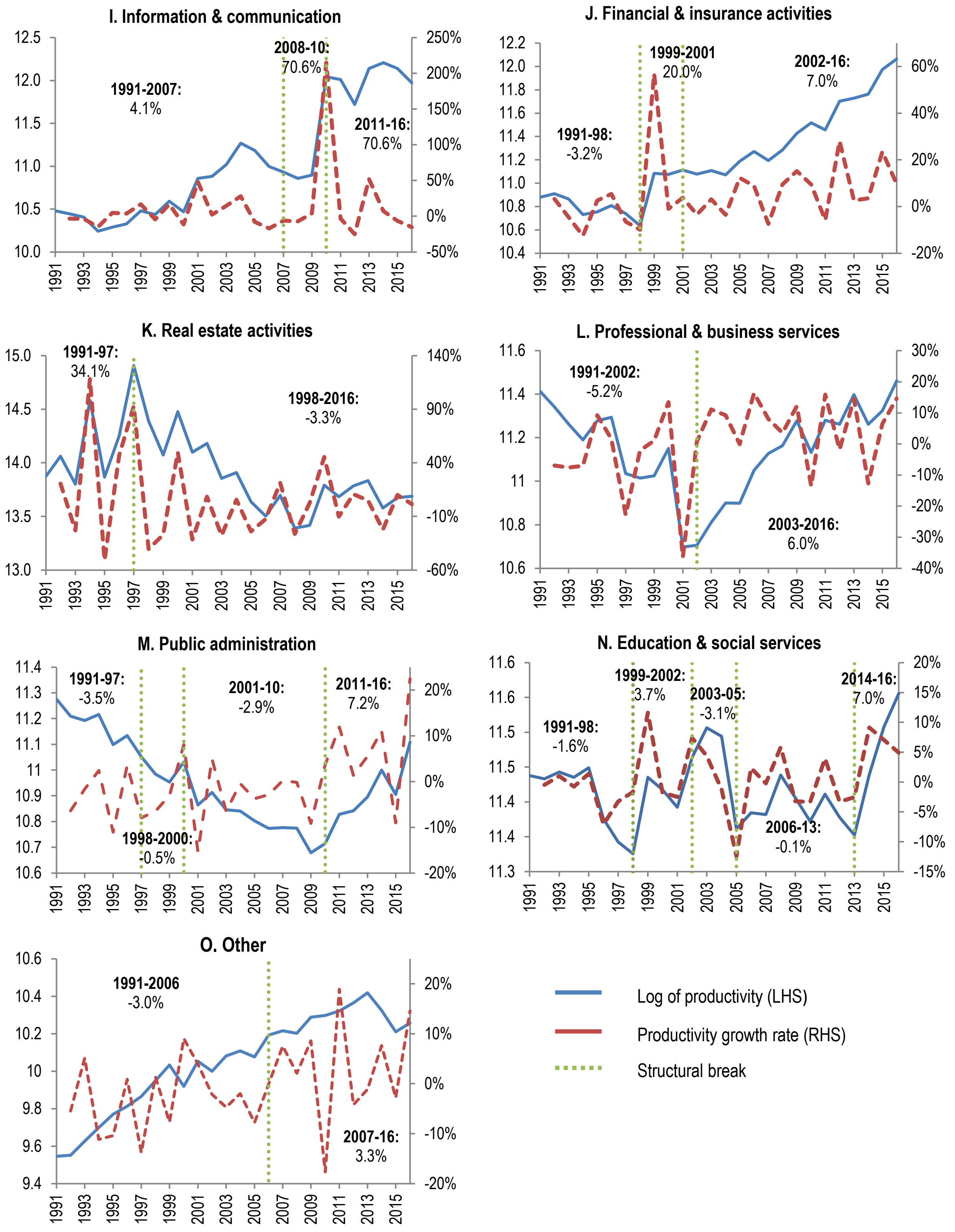
In total, over the 15 industries, 25 structural breaks were identified. The number of structural breaks varies from 0 to 4 per industry, with an average of 1.7. Two industries - construction and mining & quarrying - exhibited no clear patterns and therefore no structural breaks were identified. The majority of the identified structural breaks were positive – in 15 out of the 25 cases, productivity growth was higher after the break. Moreover, in some of these cases, such as in the information & communication industry, negative breaks represented a slowdown in productivity growth after a previous positive shift to higher growth rates. In fact, only two industries – agriculture, forestry & fishing and real estate activities – experienced only negative structural breaks over the entire 1991-2016 period (Figure 1.11).

While emerging markets typically experience increasing agricultural productivity, this has not been the case in Costa Rica over the last few decades. Existing research that specifically looks at agricultural productivity over a longer time series reveals that MFP growth has been decreasing since the 1990s despite a growth in export crops such as pineapples (Fuglie and Rada, 2016[23]). Factors which have contributed to this deceleration in productivity growth include the expansion of certain crops into less productive land, growing fragmentation of smaller farms, low education levels and a lack of skills, limited access to more efficient agrochemicals, and low-quality rural infrastructure and limited access to credit for productivity-enhancing investments (OECD, 2017[6]).

Another insight from the structural break analysis is that nine out of the 25 breaks happened between 2010 and 2013, which is within the confidence interval of the second break at an aggregate level (see $\hat{T}_2$ in Table 1.2) as well as the structural break detected for MFP. Hence, there is evidence that something influenced both industry-level and country-level productivity during those years. This is not the case for the earlier break in aggregate labour productivity, where only four out of 25 breaks occurred. While it is beyond the scope of this work to identify the possible reasons for the pattern in 2010/2011, possibilities include the economic upturn in 2010 of the US (which is Costa Rica’s largest trading partner), or the partial reform of the tax code in 2011-2012. Industry-level trends, particularly in the information & communication and financial & insurance activities industries are likely to have been influenced by the opening of the telecommunications and insurance markets to competition in 2010 and 2011 respectively.

Figure 1.11. Most industries experience positive structural breaks over the last decade





Note: Numbers in text are average annual growth rates. The left-hand y-axis corresponds to the log of productivity. The right-hand y-axis corresponds to the productivity growth rate. The dashed vertical lines correspond to endogenously determined structural breaks following Bai and Perron (2003) (see Box 1.2).
Source: Authors' calculations using Banco Central de Costa Rica data.

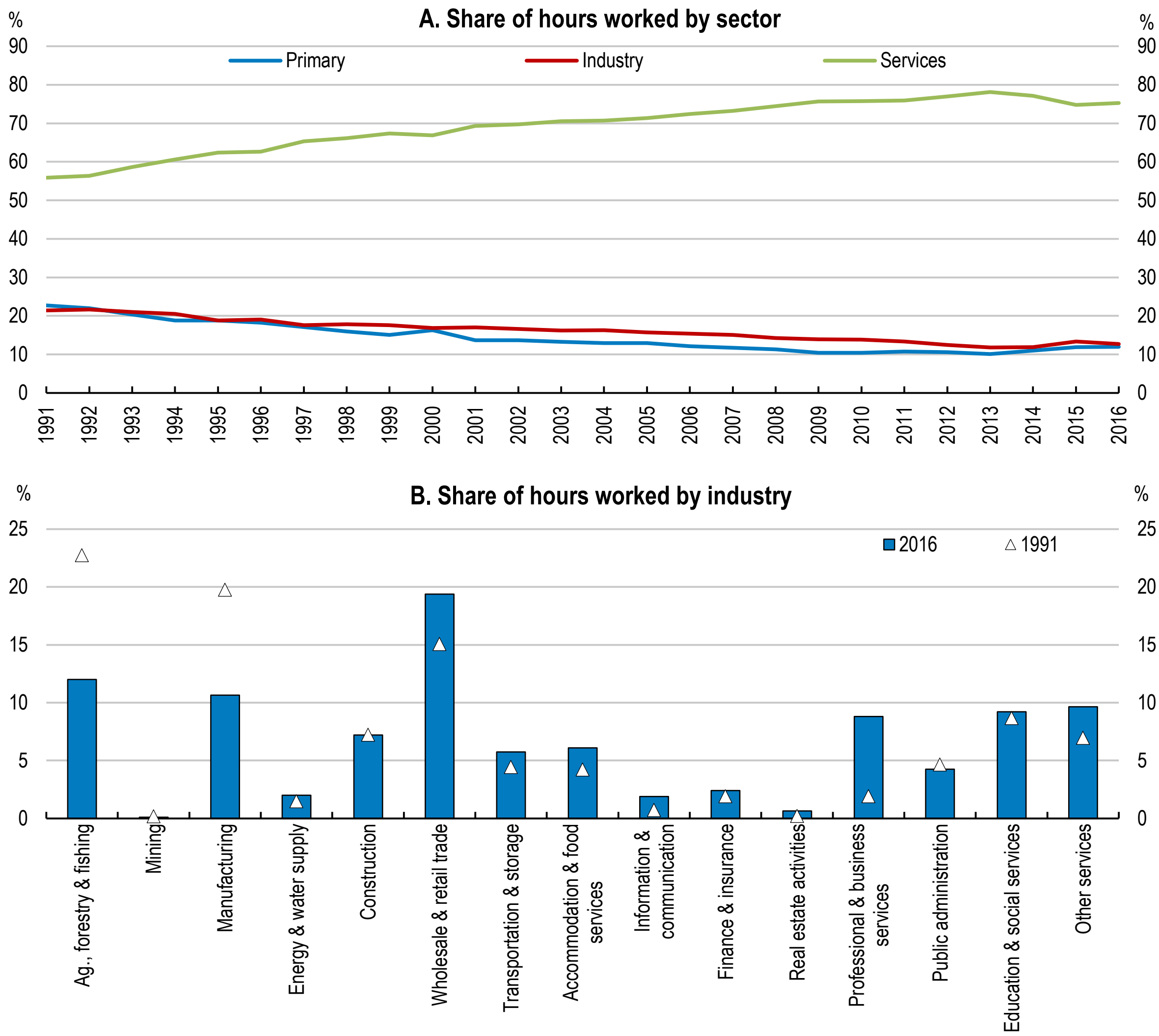
Structural change: The role of labour movements across industries

Structural change – the process of shifting towards high-productivity industries – can be an important source of aggregate productivity growth particularly in emerging economies. For example, McMillan and Rodrik (2011[24]) find that differences in structural change have been more important than within-industry productivity growth in explaining the disappointing labour productivity performance of Latin American countries relative to emerging Asian economies. Asian countries have generally experienced productivity-enhancing structural change as labour has moved from low- to high-productivity industries while labour has moved towards low-productivities industries in many Latin American countries. In particular, while labour has moved away from agriculture in both Asian and Latin American countries, it has moved towards higher-productivity manufacturing in Asian countries, but towards relatively low-productivity services in Latin American countries. In this respect, the labour movements in Latin American countries look more like those of developed countries, and the intermediate stage of structural transformation where labour moves from agriculture to manufacturing seems to have been bypassed. One of the possible reasons for this is that Latin American countries are more likely to be commodity exporters. While mining is a very high productivity industry, it does not absorb much labour, and therefore a large share of natural resources in exports is associated with productivity-detracting structural change (McMillan and Rodrik, 2011[24]; McMillan, Rodrik and Verduzco-Gallo, 2014[25]).

However, Costa Rica may not have the same patterns as a typical Latin American country as it is not a commodity exporter. In fact, since opening to trade and FDI in the 1980s, Costa Rica has been experiencing an economic transformation, and is increasingly exporting sophisticated manufactured goods and knowledge-intensive services (discussed in Chapter 3). Therefore, the contribution of between-industry labour movements versus within-industry productivity growth is explored here using shift-share analysis (see Box 1.3).

Before examining the contribution of structural change to productivity growth, a look at the movement of labour across the three broad sectors shows that, as expected, the share of workers in the primary sector has decreased over time (Figure 1.12, Panel A). In 1991, over a fifth of hours worked were accounted for by agriculture; by 2016, this has decreased to 12% (Figure 1.12, Panel B). However, employment in the relatively high-productivity industrial sector has also decreased (Figure 1.9; Figure 1.12, Panel A). Similar to agriculture, manufacturing has gone from accounting for about a fifth of hours in 1991 to about 11% in 2016 (Figure 1.12, Panel B). In contrast, the services sector has increased in size (Figure 1.12, Panel A). This pattern is typical of developed countries, where employment in services, particularly low-productivity labour-intensive services such as accommodation & food services, increases due to a combination of Baumol's cost disease and an increase in demand for these services. Baumol's disease means that labour-intensive service industries will account for an increasing share of employment as the potential for productivity growth in these industries is low compared with other industries (Baumol and Bowen, 1966[26]). At the same time, the demand for the output of these labour-intensive service industries tends to rise as incomes rise (Dennis and İşcan, 2009[27]). However, an examination of the industry-level labour movements reveals that this shift towards the services sector is not just due to the rise of low-productivity service industries. While the labour share of some relatively low-productivity service industries, such as accommodation & food services, has been growing, many of the growing service industries are relatively high-skilled and high-productivity, such as professional and business services (Figure 1.12, Panel B).

Figure 1.12. Service industries represent an increasing share of labour hours

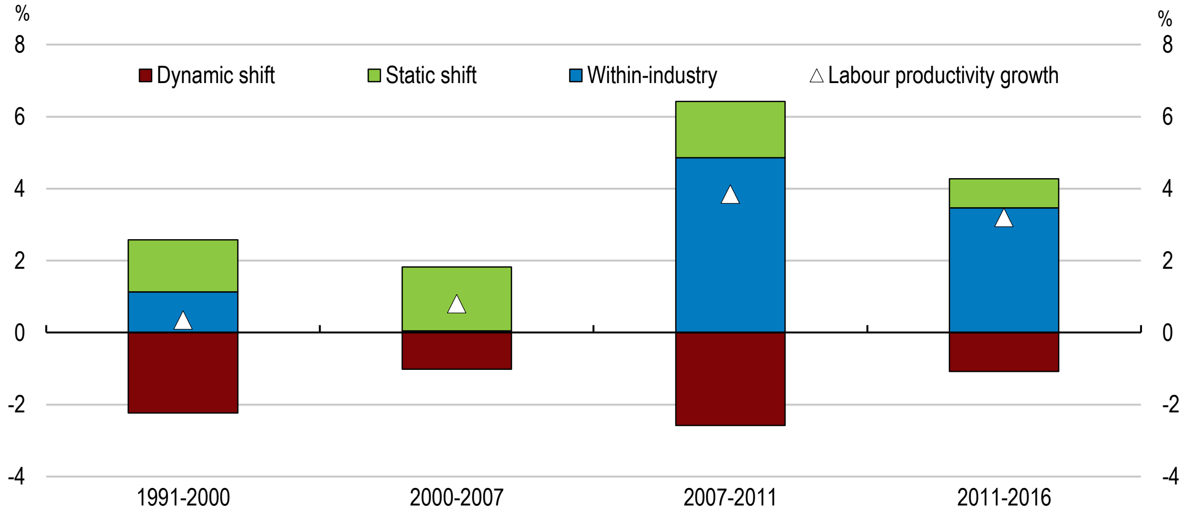


Source: Authors' calculations using Banco Central de Costa Rica data.

Turning to the shift-share analysis results, during the 1990s, modest positive within-industry productivity growth and positive static shift effects (i.e. labour moving from low-to-high productivity industries) were almost entirely offset by negative dynamic shift effects (i.e. labour moving from high-to-low productivity *growth* industries). In the early part of the 2000s, there was almost no within-industry productivity growth, with the vast bulk of aggregate growth coming from labour moving towards industries with higher productivity levels. Since 2007, within-industry productivity growth has played a much more important role, accounting for the majority of aggregate growth (Figure 1.13).

Figure 1.13. Within-industry growth is an increasingly important source of productivity growth

Contributions to average annual labour productivity growth



Note: The first two time periods correspond to the years before the first identified structural break, and the last two time periods correspond to the periods after the second and third structural break respectively (see Box 1.2)

Source: Authors' calculations using Banco Central de Costa Rica data.

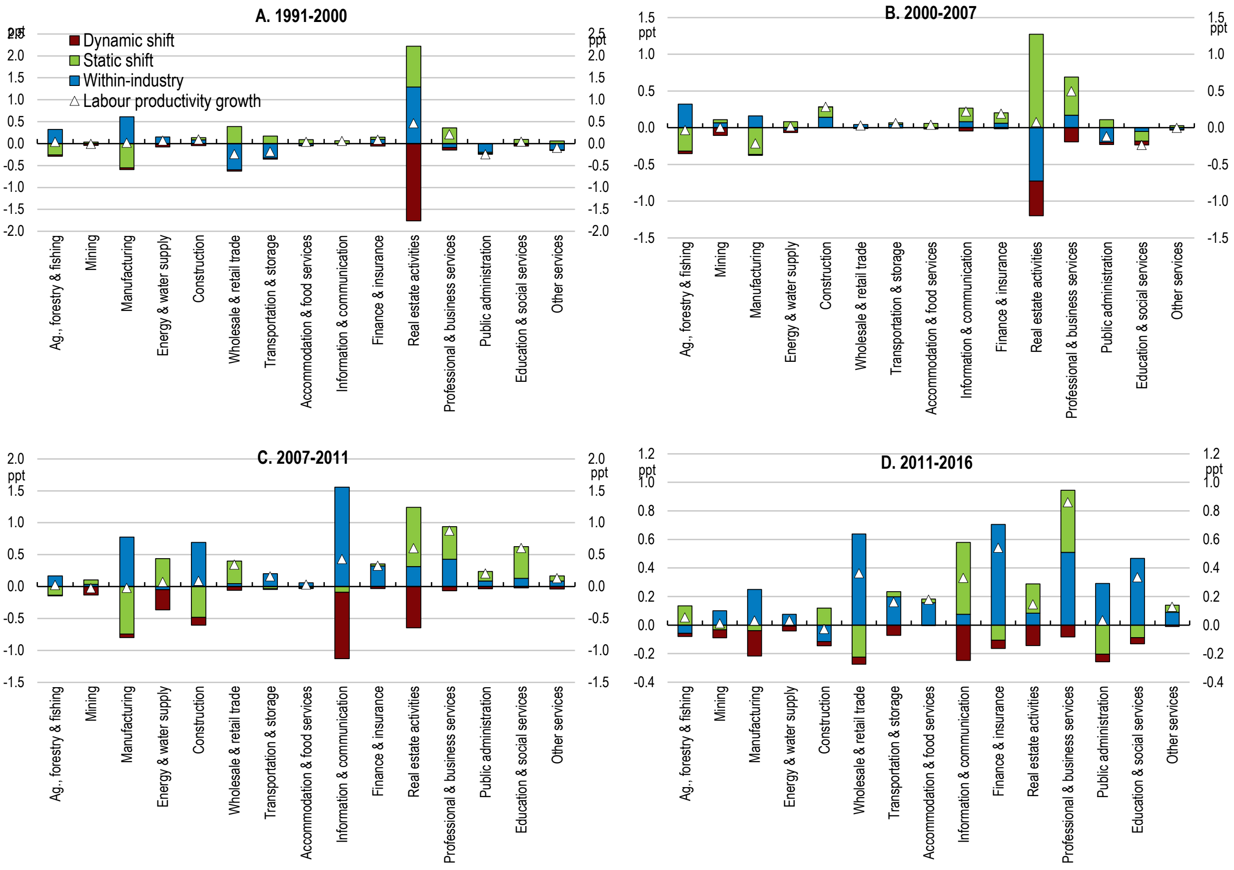
Did particular industries drive these overall patterns? The real estate activities industry has extremely high levels of labour productivity relative to other industries (Figure 1.10), therefore, relatively small shifts in labour share towards or away from this industry results in large static shift effects. Likewise, the absolute change in this industry's labour productivity can be large relative to the absolute change in aggregate labour productivity (i.e. $\Delta LP_{it} - \Delta LP_t$) even if this represents only a small change in terms of industry growth rates (i.e. $\Delta LP_{it}/LP_{it-1}$). This results in the real estate activities industry making very large contributions, particularly in the 1991-2000 and 2000-2007 time periods, even though it accounts for less than 1% of total labour hours.

In the 2007-2011 period, the number of industries making sizeable positive within-industry contributions was greater than the earlier periods, reflecting the broad-based acceleration in productivity growth discussed earlier. The information & communication industry made a large contribution to total within-industry productivity growth despite being a small industry, accounting for at most about 2% of labour hours, due to very high labour productivity growth. This is likely to be associated with the liberalisation of the telecommunications industry in 2010, as productivity in information & communication grew at an extremely high rate of 215% between 2009 and 2010. This industry also made a large negative contribution to the dynamic shift effect as this industry lost a small share of labour. During this period, manufacturing also made a large positive within-industry contribution to labour productivity growth. However, manufacturing is a diverse and large industry, and in fact, some of this measured within-industry growth may have been driven by labour movements between sub-industries within manufacturing, particularly in the shift towards medium- and high-tech manufacturing. At an even more granular level, improved resource allocation between firms within the same industry (which are examined in Chapter 4) would also show up as within-industry growth in this industry shift-share analysis. However, manufacturing had a negative static shift effect as labour shifted out of this relatively high-productivity industry.

In the 2011-2016 period, professional and business services made large positive contributions to within-industry productivity growth and the static shift effect as this industry experienced fast productivity growth and a growing share of labour hours. The most notable difference between this period and the 2007-2011 period is that the information & communication industry made only a negligible contribution to total within-industry productivity growth. Financial and insurance services made the largest contribution to total within-industry productivity growth during the 2011-2016 period. While the productivity growth of finance and insurance cannot be separated in these data, once again, it is possible that at least part of this lift in performance was due to the liberalisation of the insurance industry in 2011.

Figure 1.14. Aggregate shift-share results reflect large contributions by a few industries

Average annual percentage point contribution to aggregate labour productivity growth



Source: Authors' calculations using Banco Central de Costa Rica data.

Box 1.3. Shift-share analysis

Shift-share analysis can be used to decompose labour productivity growth into within-industry and structural change effects (Timmer and Szirmai, 2000[28]; McMillan, Rodrik and Verduzco-Gallo, 2014[25]). Following Timmer and Szirmai, Costa Rica's labour productivity growth is decomposed into i) within-sector productivity gains, ii) static shifts or shifts from employment from sectors with low productivity levels to those with high productivity levels, and iii) dynamic shifts or shifts from sectors with low productivity growth to those with high productivity growth. The sum of static and dynamic shifts is the structural change component of labour productivity growth.

Let aggregate labour productivity (LP) be the sum of industry-level value added weighted by the industry's share of hours worked[5]:

$$\boldsymbol{LP_t = \frac{Y_t}{L_t} = \sum_{i=1}^{n} \frac{Y_{it}L_{it}}{L_{it}L_t} = \sum_{i=1}^{n} LP_{it}S_{it}} \qquad \textbf{(1.5)}$$

where Y_t is aggregate value added in year t, L_t is aggregate hours worked, the subscript i=1,…,n represents each of the n sectors, and S_it is industry i's share of total hours in year t.

Using Equation 1.5 to derive the labour productivity growth rate and re-arranging gives the decomposition used in Sharpe (2010[29]) and Meehan (2014[30]):

$$\boldsymbol{\frac{\Delta LP_t}{LP_{t-1}} = \frac{\sum_{i=1}^{n} \Delta LP_{it}\, S_{it-1}}{LP_{t-1}} + \frac{\sum_{i=1}^{n} (LP_{it-1} - LP_{t-1})\Delta S_{it}}{LP_{t-1}} + \frac{\sum_{i=1}^{n} (\Delta LP_{it} - \Delta LP_t)\Delta S_{it}}{LP_{t-1}}} \qquad \textbf{(1.6)}$$

The first term on the right-hand side of Equation 1.6 is the within-industry productivity gains (the industry's productivity growth weighted by industry's share of hours, summed across industries). The second term is the static shift effect (the level of the industry's productivity relative to total productivity weighted by the change in the industry's share of hours, summed across industries). This term will be positive if labour is moving towards industries with above-average productivity levels. The third term is the dynamic shift effect (the growth of the industry's labour productivity weighted by the change in the industry's share of hours, summed across industries). This term will be positive if labour is moving towards industries with above-average productivity growth.

5 The results are similar if labour productivity is measured as value added per worker rather than value added per hour worked.

What this volume offers: Going beyond aggregate and industry trends

The aggregate and industry trends presented above are useful for providing an overview of Costa Rica's productivity performance. However, productivity research is increasingly going beyond the aggregates and exploiting microdata to gain deeper insights into the drivers of productivity (see for example, Syverson, 2011[31]). This research has been motivated, in part, by the observation that sound macroeconomic, trade, competition and education policies are necessary but generally not sufficient for productivity growth. Despite improvements in these framework policy conditions, many developed countries have not experienced the expected payoffs in terms of productivity growth, and have, in fact, experienced a slowdown in productivity growth (Drummond, 2011[32]). Therefore, microdata provides new opportunities to understand factors such as how policies can influence firm behaviour and contribute to aggregate productivity performance. For example, this research is providing new information about the role of factors such as technological diffusion among firms, integration into global value chains, resource allocation and firm dynamics in determining aggregate productivity performance (OECD, 2015[14]).

In this spirit, the remaining chapters in this volume contribute to our understanding of Costa Rica's economic performance, with a particular focus on the use of microdata. Chapter 2, by Catalina Sandoval, Francisco Monge, Tatiana Vargas (Ministry of Foreign Trade of Costa Rica), and Alonso Alfaro Ureña (Central Bank of Costa Rica), examines whether FDI spillovers in Costa Rica. The transfer of technology and knowledge from multinational companies has the potential to raise the productivity of local firms. However, the diffusion process is not automatic, and depends on factors such as the degree of integration of domestic firms into the supply chain of foreign firms. Moreover, even in cases where local firms are integrated into the supply chains of foreign firms, diffusion may be hampered if local firms lack the capacity to absorb the technology and know-how. Indeed, the international evidence on productivity spillovers from FDI is mixed, highlighting that results can vary not only by country, but also may also depend on the characteristics of the industries or firms in question. Therefore, Chapter 2 explores FDI spillovers in Costa Rica using a new firm-level database encompassing the universe of formal firms from 2005 to 2015. Unlike most existing studies in this area, the database includes information on firm-to-firm sales, which allows the authors to directly measure backward linkages between foreign firms and their local suppliers. These local firms have, on average, lower labour productivity, are smaller and are less likely to export than foreign firms. Almost a half of local manufacturing firms and a third of local services firms supply at least one foreign firm. However, only a small share of total sales by local firms are destined for foreign firms – just over 5% of the sales of local manufacturing firms go to foreign firms, and just 3% for services firms. In addition, these numbers are likely to overstate the degree of integration of local firms into the supply chains of foreign firms as the database does not include informal firms, which account for about 41% of employment in Costa Rica and are likely to have a lower probability of supplying foreign firms. However, the authors find a positive and significant effect of FDI on the productivity of local firms. Using propensity score matching techniques to mitigate self-selection issues, local manufacturing firms that supply foreign firms have, on average, 8% higher labour productivity than firms that do not supply foreign firms. Likewise, local services firms that supply foreign firms have, on average, 6.4% higher labour productivity. Moreover, their results suggest that the establishment os the business relationship with foreign-owned firms is what is driving the increase in productivity, regardless of the depth of the relationship in terms of the size of the transactions involved and the number of years the relationship lasts.

Chapter 3, by Sónia Araújo (OECD), Thomas Chalaux (OECD) and Alex Linares (OECD consultant), uses detailed product-level data to examine the level of sophistication of Costa's production structure and assess the country's opportunities to upscale into higher complexity products. It finds that Costa Rica's exports are a mix of high- and low-complexity products, and tend to be clustered into a few groups of related products. It has a strong revealed comparative advantage in a number of agricultural products, such as pineapples, banana and coffee. At the same time, it also has a revealed comparative advantage in two technological-intensive product groups: medical instruments and applications, and electrical goods. Most of Costa Rica's upscaling opportunities are in products with a high or very high degree of complexity. A comparison of upscale opportunities among Latin American peer countries reveals that Mexico is the only country for which all upscaling opportunities are in products with a very high degree of complexity. Costa Rica, like Brazil, Argentina and Colombia, have upscaling opportunities in high- and very-high complexity products, while other economies (including other Central American countries, Peru and Chile) have lower opportunities to diversify into highly complex products.

Chapters 2 and 3 highlight the importance Costa Rica's outward-oriented strategy to economic growth, which has allowed the reallocation of resources to higher-value-added activities over time. The allocation of resources between firms within the same industry is another element that can have important implications for an economy's aggregate productivity performance. For example, seminal work by Hsieh and Klenow (2009[33]) finds that while the potential productivity gains for the United States from better within-industry resource allocation were 36% in 1998, growing to about 43% in 2005, the potential gains in the People's Republic of China (hereafter 'China') and India are much larger. For India, the potential gains are around 100-128%, and for China, 87-115%. This highlights the importance of within-industry resource allocation as a potential source of cross-country differences in productivity.

Chapter 4, by Alonso Alfaro Ureña and Jonathan Garita Garita (Central Bank of Costa Rica) applies the method of Hsieh and Klenow (2009[33]) to Costa Rican firm-level data between 2005 and 2015. The authors find that the potential productivity gains from improved resource allocation among firms within the same industry is similar to Latin American countries, but greater than the gains in high-income countries. For manufacturing industries, total factor productivity would be around 10-15% higher if capital and labour were reallocated to equalise marginal products to the extent observed in the United States. However, these potential gains have reduced over time, suggesting that resource allocation has improved, which raises the possibility that this has contributed to the aggregate productivity improvements observed over the period investigated.

These papers provide useful pieces of the puzzle in advancing our understanding of Costa Rica's economic performance. International research is increasingly highlighting the importance of firm microdata in providing insights into the behaviour of firms and the underlying reasons behind aggregate and industry productivity performance. As in many countries, these data are only beginning to be explored in Costa Rica and will provide a valuable source of insights into the drivers of productivity performance in the coming years.

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Chapter 2. FDI spillovers in Costa Rica: boosting local productivity through backward linkages[6]

Catalina Sandoval, Francisco Monge, Alonso Alfaro Ureña and Tatiana Vargas

This chapter analyses productivity spillovers from FDI to local firms in Costa Rica, by building up on two different approaches, as done in Ruane and Uğur (2005[1]) and Haller (2014[2]). We use panel data with fixed effects and propensity score matching to exploit information at the firm level, comprised in a dataset covering the universe of formal firms in Costa Rica between 2008 and 2015. The analysis found robust evidence that the presence of foreign firms is positively correlated with the productivity of local Costa Rican firms in both the manufacturing and the services sectors. In the manufacturing sector, the local supplying firms have, on average, 8% higher labour productivity than those that do not have business relations with foreign-owned firms. In the services sector, local firms that are suppliers of foreign-owned firms have, on average, 6.4% higher labour productivity than those that do not have business relations with foreign-owned firms. These findings highlight the importance of FDI attraction for the Costa Rican economy as a whole and the need to deepen public policy aimed at boosting the creation of linkages between foreign-owned and local firms.

Introduction

Over the past three decades, Costa Rica has followed a consistent outward-oriented development strategy. One of its pillars has been the attraction of foreign direct investment (FDI), which, together with the process of trade liberalisation, has facilitated a relatively rapid and substantial structural transformation of the economy. Sophisticated manufacturing and high value-added services now account for a significant share of the Costa Rican economy and trade flows, having achieved higher levels of growth than activities oriented mostly to the domestic markets. A crucial question is whether deepening the channels for spillovers from FDI to the rest of the economy may contribute to a more inclusive development pathway for the country. Thus, it is of great interest to analyse productivity spillovers that could be taking place as a result of the presence of multinational companies (MNCs) in the Costa Rican economy.

[6] This study reflects only the opinions of the authors and not those of the institutions they work for, nor the OECD. The authors bear full responsibility for any mistakes or errors found in this document.

This study aims to analyse whether there is robust evidence of productivity spillovers from FDI to local firms in Costa Rica. It investigates this question by applying two different approaches to a novel firm-level database covering the universe of formal firms in Costa Rica from 2005-2015. First, an empirical model widely used in the international literature is applied, by which the productivity of local firms is regressed on a group of explanatory variables (Gorg and Greenaway, 2004[3]; Lesher and Miroudot, 2008[4]) including one that accounts for the existence of spillovers from FDI. Our specification is based on Ruane and Uğur (2005[1]) and Haller (2014[2]), which evaluate whether the presence of foreign-owned firms in Ireland raises the productivity of local firms. However, this analysis relies on industry-level measures of the presence of foreign firms. Therefore, the main contribution of this study is to analyse the existence of spillovers through firm-level information on backward linkages with foreign-owned firms, and by using Propensity Score Matching (PSM) techniques to generate a counterfactual situation to control for possible self-selection bias.

Exploiting firm-level information comprised in a dataset recently developed by the Central Bank of Costa Rica (*Banco Central de Costa Rica*, BCCR), is clearly one of the most attractive and robust features of our work. The dataset compiles firm-level data from 2005 to 2015 for revenues, costs, location, assets, exports, imports, number of employees, industrial classification (4-digit ISIC) and foreign direct investment, for all the firms that paid income taxes in the referred period. We also use labour data from the Social Security Fund (*Caja Costarricense de Seguro Social*, CCSS) for the same period and data on transactions between firms over 2008-2015.

We find a positive correlation between the presence of foreign firms and the productivity of local firms in both the manufacturing and services sectors using the approach of Ruane and Uğur (2005[1]) and Haller (2014[2]). This means that the greater the presence of foreign firms in an industry, the higher the productivity of domestic firms. However, given the limitations of measuring spillovers by an industry-level measure of foreign presence, we also use a firm-level backward linkages variable in the estimation and apply propensity score matching (PSM) techniques to account for possible selection bias. We find that local manufacturing and services firms that supply foreign-owned firms have higher labour productivity than those that do not have any business relationships with foreign-owned firms. In addition, the results suggest that the productivity benefits stem from the business relationship with FDI firms, regardless of the size of transactions and the number of years they last.

Currently, local Costa Rican firms are characterised by two different levels of performance, as some of them are fully integrated into international markets and others do not have the capabilities needed for such integration (Beverinotti et al., 2014[5]; Monge-González and Torres-Carballo, 2014[6]). This "duality" confirms that increasing the number of firms that can be linked to foreign trade and foreign-owned firms remains a major challenge. Nevertheless, the present study uses firm-level data to show that the number of local firms that have commercial relationships with foreign-owned ones is not negligible – about one third do so. Even though the figure is growing and sizeable, it should not undermine the country's efforts to continue strengthening the linkages between local and FDI firms.

The remainder of this chapter is organised into four sections. Section 2 provides an overview of the main facts relating to FDI and productivity in Costa Rica over the last three decades and of the international literature on spillovers. Section 3 describes the dataset used and the methodological approach followed, while Section 4 describes the main findings from the analysis. The last section summarises the main conclusions and discusses policy implications.

Trade liberalisation, FDI and labour productivity

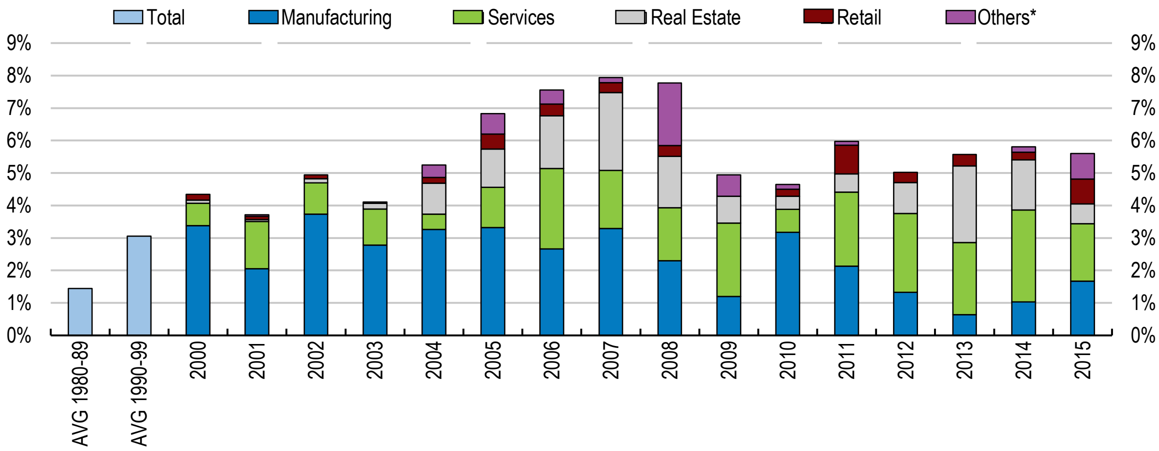
Starting in the mid-1980s, Costa Rica has pursued an outward-oriented development strategy, under which trade liberalisation and FDI attraction became key elements. For instance, the adhesion to the General Agreement on Tariffs and Trade (GATT) in 1991, and accession to the World Trade Organization in 1995, involved significant commitments by the country to reduce tariffs on imports. Furthermore, the negotiation of bilateral and regional foreign trade agreements (FTAs) has complemented multilateral efforts and deepened trade liberalisation. Since 1995, when Costa Rica signed a bilateral FTA with Mexico, 13 FTAs have been negotiated and implemented, providing for preferential access, certainty and predictability for nearly 90% of the country's trade in goods.

The FDI attraction strategy also began in the 1980s. The main actions that marked the first steps of this initiative involved the creation of the Costa Rican Coalition of Development Initiatives (CINDE), which is the agency responsible for the promotion and attraction of foreign direct investment. Also, the Free Trade Zones Regime (FTZ) was created in the early 1980s – which grants tax exemptions to companies that make new investments in the country and comply with a series of requirements – with the main objective of promoting exports of non-traditional goods and developing strong linkages with international markets. In turn, and as highlighted by international literature, it was also anticipated that encouraging FDI would bring new technologies and management knowledge that, if adopted to some extent by domestic firms, would generate positive productivity spillovers (Markusen, 1995[7]). Recognising this potential, some programmes to promote productive linkages between MNCs and local firms have been established in Costa Rica, such as *CR Provee*. However, while more evidence is needed of its effectiveness, some positive impacts on wages, labour demand, and chances of exporting of local supplier firms have been found (Monge-González and Rodríguez-Álvarez, 2013[8]).

Reflecting these outward-oriented strategies, FDI has increased significantly over time. In the period 1980-89, FDI amounted to, on average, 1.5% of GDP a year, a figure that doubled for the next ten years and then reached 5.6% of GDP between 2000 and 2015. In the beginning, a substantial share of the investments took place in manufacturing, but in the last five years, they have shifted towards the services sector, thus producing a noticeable change in the sectoral composition (see Figure 2.1).

Figure 2.1. Inflows to FDI into Costa Rica by sector, 1980-2015

As share of GDP



Note: * "Other" includes agriculture, food industry, and others.
Source: Authors' calculations using data from BCCR.

About 37% of annual FDI inflows went into the FTZ regime in the 2000-2015 period, thus increasing the contribution of FTZs to the country's exports. In 1995, firms operating in FTZs accounted for 12.3% of goods exports, while for 2000-2015 the figure increased to almost 50%. Another relevant feature is that FDI has contributed significantly to export diversification. In the manufacturing sector, textiles and clothing activities were replaced by others with a higher level of sophistication, such as electronics and, more recently, a rapidly growing medical devices cluster (Sandoval et al., 2017[9]).[7] In turn, the already mature tourism industry has combined with the opening of the telecommunications industry to private investment in 2011 and the outstanding performance of information technology (IT) and business support services, to produce a substantial increase in services exports, whose share in total exports reached nearly 46% in 2017 (Sandoval et al., 2017[9]). Nevertheless, the country's investment in R&D, the availability of researchers and production of patents remain low in comparison with OECD countries, thus hindering the potential to increase the establishment and development of further complex industries (OECD, 2017[10]). In addition, Costa Rica is now well integrated into global value chains from a backward participation perspective, with a share of foreign value added in gross exports that is similar to that of Mexico. However, Costa Rica remains below peer countries regarding its forward participation in global value chains – that is, the share of Costa Rican value added embodied in foreign countries' exports is low (Araújo and Linares, 2018[11]).

Despite this rise in FDI and integration into global value chains, productivity in Costa Rica grew only slightly over 1950-2010, such that doubling its levels would take about half a century (Alfaro Ureña and Vindas Quesada, 2015[12]). This result is attributed to slow productivity growth in the services sector at large (which encompasses all non-

[7] Over the years 2014-15, the electronic components sector has undergone on a significant transformation – shifting away from manufacturing towards high value-added sophisticated services – and the sustained growth of medical device manufacturing and services activities have contributed to smooth the overall impacts of this transition (Sandoval et al., 2017[9]).

tradable services), which has also increased as a share in the economy (Alfaro Ureña and Vindas Quesada, 2015[12]). A review of productivity in the last fifteen years suggests that there is a duality in the performance of services sectors. Some sectors grow and others do not, the last one is the case of community, social and personal services; electricity, gas and water, and public administration services (Mulder, Patiño-Pascumal and Monge-González, 2016[13]).

In addition, there is some duality among companies that operate under different regimes and that may be related to the problem of slow productivity growth. On the one hand, there are multinational companies and their specialised suppliers; on the other hand, a myriad of local firms (Beverinotti et al., 2014[5]; Monge-González and Torres-Carballo, 2014[6]). The latter are mostly small and medium enterprises (SMEs), which are dedicated to producing for the local market and are involved in a business climate with high obstacles; these factors suggest that this group of firms pushes aggregate productivity levels downward (Monge-González and Torres-Carballo, 2014[6]). This raises the question of whether, and to what extent, the presence of foreign-owned firms has resulted in higher productivity among domestic firms.

The existing literature highlights a number of possible channels through which FDI can influence the productivity of domestic firms. Horizontal spillovers, when a foreign firm enters the same industry as domestic firms, can improve the productivity of local firms via the labour mobility of human capital trained in multi-nationals, imitation and observational learning and increased competition (Gorg and Greenaway; Paus 2014). For example, in Costa Rica, some analyses of the local suppliers that received training from MNCs located in the FTZs suggest that all surveyed firms were using new know-how acquired from MNCs to produce goods and services to sell to other Costa Rican firms (Monge-González, Rosales-Tijerino and Arce-Alpízar, 2005[14]). Furthermore, with regard to local supplier firms created by former employees of MNCs in Costa Rica, it was found that at least one of their owners had previously worked for MNCs operating in the country (Monge-González, Rosales-Tijerino and Arce-Alpízar, 2005[14]).

However, spillovers are not automatic, and will depend on the capacity of local firms to absorb new ideas and methods. In addition, while technological spillovers are clearly positive, the impact of greater competition is ambiguous. Competition may force local firms to improve their productivity and efficiency, or levels of innovation, in order to survive (Blomström, 1986[15]). On the other hand, local firms may be crowded out by more efficient foreign entrants. Indeed, the empirical evidence relating to horizontal spillovers is mixed. For example, Haskel, Pereira and Slaughter (2007[16]) find evidence that an increased foreign presence in the UK manufacturing sector raised the productivity of domestic firms in the same industry. However, negative effects of FDI on domestic productivity have been found for Morocco (Haddad and Harrison, 1993[17]), Venezuela (Aitken and Harrison, 1999[18]), and the Czech Republic (Stančík, 2007[19]). The existing work on Ireland most closely resembles the methodological approach taken to examine horizontal spillovers in this paper. Ruane and Uğur (2005[1]) find weak evidence of positive spillovers on the productivity of local manufacturing firms, and Haller (2014[2]) finds insignificant or even negative effects of foreign presence on local Irish firms in the services sector.

Vertical spillovers are also possible. These occur when the presence of foreign firms in one industry increases the productivity of domestic firms in connected industries where there is no direct competitive pressure from foreign firms. These can involve backward spillovers (when local suppliers in upstream industries supply inputs to foreign firms in downstream industries), or forward spillovers (when foreign firms in upstream industries sell their outputs to domestic firms in downstream industries). Unlike horizontal spillovers, competition issues do not apply, so foreign firms do not have incentives to prevent technology diffusion to upstream or downstream industries, suggesting that spillovers may occur more readily. This can involve, for example, foreign firms directly transferring technology or providing technical assistance and training to local suppliers, or requiring higher quality standards and thereby incentivising local firms to upgrade their production, management and technology (Aitken and Harrison, 1999[18]; Javorcik, 2004[33]). On the other hand, backward spillovers may be constrained by several factors. Foreign firms may choose to import intermediate goods instead of sourcing them locally (Rodriguez-Clare, 1996[20]). Or even when a foreign firm sources intermediates locally, the suppliers may fail to learn and absorb new technology and processes if they lag too far behind their foreign partners and therefore lack the absorptive capacity to benefit (Javorcik, 2004[21]; Lin and Saggi, 2007[22]).

Costa Rica is a small economy and, thus, most of the foreign investment that is attracted does not seek to supply the local market. Instead, the strategy followed by FDI firms has been to find efficiency through cost reduction (Martínez and Hernández, 2012[23]). Therefore, the benefits from the establishment of MNCs are most likely to occur through backward linkages. However, the empirical evidence on backward linkages is also mixed. Positive backward spillovers have been found for 17 emerging economies (Gorodnichenko, Svejnar and Terrell, 2007[24]), Indonesia (Javorcik, 2004[21]), Lithuania (Schoors and van der Tol, 2002[25]) and Canada (Wang and Gu, 2006[26]). However, Stancik (2007[19]) finds that the presence of foreign firms has a negative impact on upstream local firms in the Czech Republic. In a study of 25 developed and emerging economies in the EU, the effect was found to be very small, particularly for emerging markets (Fons-Rosen et al., 2013[27]).

Moreover, the country faces a skills mismatch with various adverse effects in the relations with MNC, such as: i) the attraction of the best-qualified personnel by MNC offering higher wages, leaving the domestic enterprises short of this type of human capital; ii) limiting MNC to engage to higher-value added activities; and iii) a shortage of highly qualified researchers in both the private and the public sectors. This evidences a paradox: while more high-skilled workers are demanded, most of those who work for MNC are overqualified for the jobs they are performing (OECD, 2017[10]).

Despite some evidence of the positive results of the *CR Provee* programme to provide linkages between domestic and foreign firms and subjective surveys on the interactions between these firms, the existing literature has not been able to provide systematic evidence on FDI spillovers to domestic firms. Further policy interventions have been undertaken to increase the absorptive and innovative capacities of domestic firms. However, the size and scope of these programmes are too small to have a sufficient impact and trigger a change in Costa Rica's innovation capabilities and to boost productive linkages between MNC and domestic firms (OECD, 2017[10]). In addition, the international evidence highlights that the benefits from spillovers are influenced by several factors, and therefore can vary from country-to-country. Moreover, many existing studies rely on input-output tables to estimate backward spillovers. We exploit a novel dataset that provides information on transactions between individual firms, providing a more direct way to measure business relationships between local and foreign firms. Therefore, it is of great interest to analyse productivity spillovers that could be stemming from the presence of MNCs) in Costa Rica.

Data and methodology

Data

The quantitative analysis of this study uses a dataset compiled and administered by the BCCR, which comprises firm-level data for the universe of formal firms operating in the country during the period 2005-2015. This dataset includes information from several sources that the BCCR has merged into a complete set of consistent data. The variables available in the database include: employment (which comes from the CCSS); exports and imports of goods[8] (which come from Costa Rica's export promotion agency, PROCOMER, and BCCR, respectively); profits, revenues, costs, and assets (which are reported by firms to the Ministry of Finance by means of the mandatory income declaration form D101); transactions between firms (which come from the work by Alfaro Ureña, Manelici and Vasquez, 2018[28])[9]; geographic location and main economic activity of each firm; and whether each firm is locally or foreign owned.

The definition of foreign ownership lies on the share of equity owned by foreign investors. The threshold used in several empirical studies is 10% (Javorcik, 2004[21]; Ruane and Uğur, 2005[1]). However, for the period analysed, all the firms with foreign capital in Costa Rica are 100% foreign owned, while domestic firms are 100% locally owned.

This work focuses on firms in manufacturing (10-33) and services (41-63 & 69-96) industries, corresponding to the two-digit International Standard Industrial Classification (ISIC). Firms in activities of agriculture, forestry, and fishing (01-03); mining and quarrying (05-09); financial activities (64-66); public institutions (84) and NGOs, were ruled out. Firms that hire less than three employees for the whole period were excluded in order to prevent possible unusual behavior in the productivity of very small firms. Firms in the tails of the distribution of the dependent variable (the top and bottom 1%) were also excluded as outliers. Three-digit ISIC industries with five or fewer firms and two-digit ISIC industries with ten or fewer firms were excluded as well, to safeguard the confidentiality of firms' data.

Only industries at the three-digit ISIC level with the presence of local firms that sell to foreign-owned firms in the year were considered, in order to keep fully comparable industries in terms of linkages to foreign-owned firms. Data cleaning was also carried out to exclude observations with missing values. The final sample contains 30,464 unique firms that vary between 13,294 and 21,779 per year, and 145,921 observations.

The labour productivity of a firm is measured as the ratio of revenues (Y), in millions of local currency[10], to total employment (L). Revenue data is deflated using the Consumer Price Index (CPI) from the BCCR (September 2013=100). There are four independent variables used to measure FDI participation or linkages of domestic firms to foreign firms. The first one is the foreign presence (FP) in the industry, which is an aggregated variable that measures the share of employment accounted by all foreign-owned firms in the relevant industry. The second one is Sales, a firm-level variable that represents the

[8] Data available in the BCCR's database does not include services trade flows.

[9] They built variables over transaction data from the declaration of suppliers, D-151, ("Declaración anual resumen de clientes, proveedores y gastos específicos") for the period 2008-2015

[10] Costa Rican "colón".

share of sales to foreign-owned firms. This variable, developed by Alfaro Ureña, Manelicci, and Vasquez (2018[28]), is built upon the supplier declaration form data D-151, which considers all sales of domestic to foreign firms over a minimum value of approximately $5,000 per year (or $100 in the case of professional services). Then, sales information is used to compute a dummy variable that takes the value of one if the local firm sells to foreign-owned firms in the specific year, or zero otherwise. In addition, a "dosage" variable is measured as the cumulative number of years that a local firm sold to foreign-owned firms.

Other variables are also estimated at the firm level. Capital intensity $\left(\frac{K}{L}\right)$ is computed as the log of the ratio of total net assets (K), deflated by CPI, to total employment (L). Labour quality $\left(\frac{L_S}{L}\right)$ is represented by the firm's share of skilled workers (L_S) in total labour. As no precise information on skilled workers is available at the firm level, a proxy was used by measuring the count of employees in each firm with a monthly wage that is greater or equal than the minimum wage[11] paid to workers that have upper secondary education with technical qualifications (known as "técnico medio en educación diversificada")[12]. Firm size is measured by four separate dummy variables that take each the value of one if the firm satisfies the criteria corresponding to each size category (micro, small, medium and large), following the algorithm set out by the Ministry of Economy, Industry and Commerce of Costa Rica (MEIC) that encompasses three elements: the number of workers, revenues and total net assets. In addition, an export status dummy was built with information of goods exports, thus taking a value of one if the firm exported goods that year, and zero otherwise.

At the industry level, the following variables proposed in Haller (2014[2]) are estimated: a lagged variable of import competition, measured as the share of apparent domestic consumption sourced through imports at the two-digit ISIC level; a Herfindahl-Hirschman index (HHI) measuring market concentration by industry at three-digit level ISIC code; and a variable on industry dynamism, that is measured as the lagged growth rate of revenues by industry at the three-digit ISIC level.

Methodology

In order to estimate the spillover effects of FDI on productivity of Costa Rican local firms, this work follows an empirical model widely used in international literature, in which the productivity of local firms is regressed on a group of independent variables that are theoretically associated to it (Gorg and Greenaway, 2004[3]; Lesher and Miroudot, 2008[4]). The set of explanatory variables the literature recommends to use may vary contingent on the measure of productivity chosen and the question being examined. For this study, the analysis builds upon the work by Ruane and Uğur (2005[11]) and Haller (2014[2]), as both works investigated the existence of FDI productivity spillovers through the presence of foreign firms on local Irish firms, for the manufacturing and the services sectors, respectively. However, the main contribution of this study is to analyse the existence of spillovers through backward linkages with foreign-owned firms, by using Propensity Score Matching (PSM) techniques to generate a counterfactual situation where productivity is measured in the absence of the backward linkages. The general model and the methodological details of this work are explained below.

[11] Wages were round to the nearest ten to consider overtime payment in the less qualified jobs.

[12] Costa Rica has 23 minimum wage categories.

Spillovers through foreign presence

The general model represents the idea that the firm's productivity is a function of production factors like capital (K), workers (L), and other determinants of productivity (e), that are not measured (Griliches, 1979[29]).

$$\boldsymbol{Productivity = f(K, L, e)} \qquad \textbf{(2.1)}$$

Other factors collected by the term "e" may include technology, R&D practices, and the spillover generated by the establishment of FDI in the country. This may represent potential gains in productivity of local firms and workers resulting from the diffusion of knowledge and technology from foreign investors to domestic firms (Caves, 1974[30]).

Model specification for manufacturing

In order to identify the aforementioned factor, and following the proposal of Ruane and Uğur (2005[1]), the labour productivity of local manufacturing firms could be defined by the following equation:

$$\boldsymbol{ln\left(\frac{Y}{L}\right)_{ijt} = \beta_0 + \beta_1 ln\left(\frac{K}{L}\right)_{ijt} + \beta_2\left(\frac{L_s}{L}\right)_{ijt} + \beta_3 FP_{jt} + \alpha_i + \alpha_t + e_{ijt}} \qquad \textbf{(2.2)}$$

where the subscripts i, j and t refer to firm, industry and year, respectively. The dependent variable, $ln(Y/L)$, is the log of labour productivity. The explanatory variables are the log of capital intensity, $ln(K/L)$, and the share of highly-skilled workers, (Ls/L). Both variables are directly associated with factors of production and thus a positive relationship between productivity and each one of them is expected. The most relevant independent variable for the purpose of this study is the presence of foreign firms at the industry level, FP_{jt}. If there are benefits of FDI for the productivity of local firms, the coefficient of the variable FP_{jt} would be positive and that would indicate that the level of productivity of the firms is higher in the industries with a higher presence of foreign firms. This variable is aggregated at both the two-digit and three-digit ISIC level to test for the robustness of the results.

The effect of productivity spillovers on local manufacturing firms in Equation (2.2) is estimated throughout panel data techniques with fixed effects, to control by characteristics of the firms that do not vary with time and could be correlated with the presence of foreign firms. In addition, a time dummy variable for each year is included, to control for possible temporal effects (α_t). Whereas e_{ijt} encompass all the other factors that affect the labour productivity of the firms that are not specified in the regression.

Model specification for services

The empirical specification for services follows the work by Haller (2014[2]), which seeks to estimate the FDI spillover effects on the productivity of local firms by measuring foreign presence and including control variables, both at the sector level. Equation (2.3) shows the general model:

$$\boldsymbol{ln\left(\frac{Y}{L}\right)_{ijt} = \alpha_i + \beta_1 FP_{ijt-1} + \beta_2 impcom_{jt-1} + \beta_3 HHI_{jt} + \beta_4 \Delta rev_{jt-1} + \alpha_t + e_{ijt}} \quad \textbf{(2.3)}$$

where the subscripts i, j and t refer to firm, sector and year, respectively. The dependent variable is the labour productivity represented by $ln(Y/L)$. The first independent variable is foreign presence, where FP_{ijt-1} represents the share of employment by foreign-owned firms in total employment in each sector, the year before. Lagging this variable is aimed at ensuring that in year t of production for local firms, the new foreign-owned firms have already been established. If there are benefits from FDI to local firms, the coefficient of the variable would be positive, and that would indicate that the level of productivity of firms is higher in industries where there was more presence of foreign owned firms the year before.

The *impcom* variable means import competition and represents a possible knowledge transfer channel from foreign-owned firms to local firms, which could have a positive effect on the productivity of the latter. In addition, a measure of market concentration, represented by a Herfindahl-Hirschman Index (HHI), is included to consider that the level of competition in the domestic market is possibly correlated to the productivity of local firms. A high HHI value indicates high concentration or relatively lower chance for competition. A higher level of competition could mean either lower or higher margins to benefit from spillovers, depending on the incentives and the capacity to use those (Farole and Winkler, 2014[31]).

Similar to the competition issue, some industry dynamics could be more appealing to foreign investors, who will probably choose to invest in sectors with better performance. To control for this, as Haller (2014[2]) does, the growth rate for revenue at three-digit ISIC level is included with a lag, to consider that the decision of investing today may be based on information about the previous period.

Although this methodology has been widely applied, a limitation of estimating spillover effects through the use of industry-level variables is that the coefficient will surely be capturing a set of dynamics. For example, factors such as worker turnover or the competition for resources in general, supply chain relationships (either backward or forward linkages), may take place simultaneously, which makes it difficult to identify the strongest mechanism for the transmission of spillovers. This work makes an important contribution by using a variable of backward linkages and an alternative methodology to identifying spillover effects on productivity from FDI.

Spillovers through backward linkages[13]

Backward linkages – that is, domestic firms supplying intermediate inputs to foreign firms - may be the most likely channel through which spillovers will take place (Javorcik, 2004[21]). To know the effect that being a supplier has on the productivity of a local firm, it would be ideal to observe its productivity, at the same time, in two scenarios: with the supplier relationship and without it. Nevertheless, this is impossible.

[13] The results for a specific industry do not mean that local firms in that industry were necessarily transacting with foreign firms in that same industry. Results for business services firms mean local business services firms supplying any foreign firm (regardless of industry).

One way to represent it is by generating a counterfactual situation that simulates what would have happened to the productivity of the supplier firms if they had not been suppliers of foreign firms (Bernal and Peña, 2011[32]). Therefore, the productivity of non-supplier firms could be taken and compared with that of the suppliers. However, becoming a supplier is not a phenomenon that occurs randomly. Generally, firms must have high-quality products and meet certain conditions and requirements in order to sell their products to foreign firms (Javorcik and Spatareanu, 2009[33]). That is, self-selection bias is an issue because supplier firms tend to be different from non-suppliers in certain characteristics that could be associated with higher levels of productivity

To address this issue, we use the Propensity Score Matching (PSM) method that is applied in observational studies to estimate causal effects (Rosenbaum and Rubin, 1983[34]). This method is based on certain observable characteristics of the units exposed to the intervention to select units that are very similar in said characteristics, but that have not been treated ("control group"), thus creating a counterfactual scenario (no intervention). The relevant characteristics ("X") are correlated with the outcome Y, but not with the treatment. If the groups are, on average, similar in values of X, the difference in Y can be attributed to the intervention. In this case, the units of analysis are the local firms and the intervention or treatment is to be a supplier of foreign-owned firms. A fundamental assumption for obtaining a good representation of the counterfactual is that the treatment and control groups resemble each other not only in the observable characteristics but also in the unobservable. A violation of this assumption would result in a biased estimate of the effect of being a supplier on productivity.

The first step is to estimate the Propensity Score (PS) or the probability of each firm being a supplier for the baseline year, that is, when none of the local firms has been a supplier of a foreign-owned one. This would ensure compliance with the assumption of unconfoundedness, which requires that the intervention does not affect X. However, the data of transactions between companies do not indicate the date on which the business relationship began, but only whether the relationship existed or not. This represents a problem for firms that supplied from the first year they appeared registered in the database, since it is not possible to identify a baseline for them. A total of 8,732 firms have this condition and are ruled out of the PS estimate. The resulting sample consists of 21,730 unique firms (97,940 observations) of which 4,224 are the treated group and 17,506 are the untreated group. The treated group includes firms that reported sales to foreign-owned firms at least one year from the second year that they appear registered onwards, while the untreated group have firms that did not register sales to foreign-owned firms for the whole period of analysis. The PS is estimated for this sample with variables that each firm scored during the first year, mostly in 2008 (39%) and 2009 (10%).

A key assumption in the estimation of PS is the common support in the treated and untreated groups, which requires the existence of positive probabilities and common areas on the probability distribution of the two groups to guarantee that firms with the same X values have a positive probability of being both participants and non-participants (Caliendo and Kopeinig, 2008[35]).

To estimate the PS, a probability model is used where the dependent latent variable is$Supplier$, a dichotomous variable that equals one if the local firm sold to foreign-owned firms at least one year from 2009 onwards, or zero otherwise. $Supplier$ is determined by a set of independent variables that have not been affected by the treatment, such as fixed factors or variables that are collected before treatment and correlated with productivity. The probability model can be represented by Equation (2.4) next:

$$\begin{aligned} \boldsymbol{Supplier_i} &= \boldsymbol{\beta_0} + \boldsymbol{\beta_1 ln}\left(\frac{\boldsymbol{K}}{\boldsymbol{L}}\right)_{\boldsymbol{i}} \\ &+ \boldsymbol{\beta_2}\left(\frac{\boldsymbol{L_s}}{\boldsymbol{L}}\right)_{\boldsymbol{i}} + \boldsymbol{\beta_3 export_i} \\ &+ \boldsymbol{\beta_4 micro_i} + \boldsymbol{\beta_4 small_i} \\ &+ \boldsymbol{\beta_5 prov_i} + \boldsymbol{e_i} \end{aligned} \quad \textbf{(2.4)}$$

where the subscript i refers to the firm. The determinants of being a supplier are the log of capital intensity, $ln(K/L)$ and the share of qualified workers (Ls/L). Both variables are associated with factors of production and a positive relationship would be expected between the probability of being supplier and each one of them. Another determinant included is the firm's size, to control for the possible preference of foreign-owned firms to do business with large firms. To this end, there are two dummy variables that equal one if the firm is micro or small size, respectively, and zero otherwise. The expectation is that micro and small firms have lower probability of becoming suppliers of foreign-owned firms.

In addition, exporters may be more likely than other firms to do business with foreign-owned firms, in light of their expertise in dealing with foreign buyers and the ability to satisfy international standards (Javorcik and Spatareanu, 2009[33]). Thus, a dummy variable is included that is equal to one if the firm is an exporter of goods, and zero otherwise. Finally, a dichotomous variable of *province* was included, being equal to one if the firm is located in San Jose (Costa Rica's capital city), where the largest portion of foreign-owned firms are located, and zero otherwise.

Once the probability of the firms – either treated or not – of being suppliers is estimated, the control group can be selected. This is done using the Nearest Neighbor Matching Algorithm, by choosing for each treated observation one (or several) non-treated observation(s) that is (are) very similar in the probability of being treated (Caliendo and Kopeinig, 2008[35]). In this case, each treated unit is matched with a neighbor and the selection is made with replacement, thus entailing a trade-off between bias and variance. The bias is reduced because more similar units are matched, but in both cases, there is an increase in the variance of the estimator due to a smaller sample size. Additionally, the caliper is used, which is a maximum level of tolerance for the distance between the probability of the firm and its control; therefore, couples will be close in probability by a magnitude equal to or smaller than the caliper.

The group of supplier firms and their respective controls form the sample used to estimate the spillover effects. The estimation is made using a panel data model with fixed effects, to control for the invariant factors over time and using weights that are the inverse probability estimated by the probit model. Equation (2.5) displays the fixed-effect panel data model to estimate:

$$\begin{aligned} \boldsymbol{ln}\left(\frac{\boldsymbol{Y}}{\boldsymbol{L}}\right)_{\boldsymbol{it}} = \boldsymbol{\alpha_i} + \boldsymbol{\beta_1 Seller_{it}} + \sum_{\boldsymbol{k=2}}^{\boldsymbol{7}} \boldsymbol{\beta_k x_k} + \boldsymbol{\alpha_t} \\ + \boldsymbol{e_{it}} \end{aligned} \quad \textbf{(2.5)}$$

where the dependent variable is the log of labour productivity and the independent variable of interest is $Seller_{it}$, a dichotomous variable that assumes the value 1 if the local firm sells in the respective year to a foreign-owned firm, and 0 otherwise. The subscript k indicates the number of control variables x included in the panel regression that are determinants of the probability of being a supplier (capital intensity, skilled employment, two firm size dummies and exporting status) and industry-level variables (import competition, concentration index and revenue growth). In addition, fixed effects α_i and temporal effects α_t, are included, while e_{it} is the error term.

Additionally, two variations of the variable of interest are considered: $Sales_{it}$, which is the share of annual sales to foreign-owned firms; and $Dosage_{it}$, a measure of the frequency of being a supplier, which accumulates the number of years that a firm has sold to foreign-owned firms (Monge-González and Rodríguez-Álvarez, 2013[8]).

Results

This section presents descriptive statistics that characterise the set of data used and the estimation results obtained by applying panel data methods and PSM. The estimation results are presented separately according to the independent variable of interest under analysis – either foreign presence or backward linkages – and according to the productive sector –manufacturing or services. Also, the results of the effects of backward linkages by sub-sector are shown. Finally, the results of a robustness test are presented.

Descriptive statistics

The descriptive statistics of the variables measured at the firm level are presented in Table 2.1 for foreign-owned firms, as well as for manufacturing and services domestic firms, over the 2008-2015 period. Foreign firms have about 47% higher productivity than local firms. They also have a higher share of skilled employees and are larger on average, as well as being more likely to export than local firms. Just over one half of foreign-owned firms are located in San José, while 16% are located in Heredia –the province with the largest presence of firms operating in Free Trade Zones in the country–, while Limón is the province with the less presence.

Most of the domestic firms are micro or small (79%), belong to the services sector (87%) and only a few are exporters (6%). Domestic services firms are on average more productive than manufacturing firms[14], and have a higher share of skilled employment. In turn, the participation of local manufacturing firms as suppliers of foreign-owned firms is around 47%, while for services it is 33%.

[14] Because the dataset includes formal firms only, it is likely excluding an considerable group of small services firms with low productivity, that likely to at least partly, reflect of this result.

Table 2.1. Descriptive statistics of firm-level variables, 2008-2015

Variable	Foreign firms		Domestic firms					
			All		Manufacturing		Services	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Dependent variables								
Y/L	59.84	64.28	40.62	45.27	34.44	35.49	41.51	46.45
ln(Y/L)	17.42	1.01	17.07	0.95	17.00	0.84	17.08	0.96
Interest variables								
Sales (%)	4.94[a]	13.3[a]	3.20	11.66	5.10	13.92	2.93	11.27
Seller	0.66[a]	0.48[a]	0.35	0.48	0.47	0.50	0.33	0.47
Dosage	2.79[a]	2.59[a]	1.32	2.01	1.88	2.29	1.24	1.95
Control variables								
ln(K/L)	17.17	1.57	16.21	1.51	16.09	1.34	16.23	1.53
Skilled workers (%)	65.1[b]	30.6[b]	26.12	32.60	22.89	29.31	26.59	33.02
Exporter	0.41	0.49	0.06	0.23	0.15	0.36	0.04	0.20
Services sector	0.75	0.43	0.87	0.33	0.00	0.00	1.00	0.00
Firm size								
Micro	0.06	0.23	0.41	0.49	0.55	0.50	0.39	0.49
Small	0.19	0.39	0.39	0.49	0.30	0.46	0.40	0.49
Medium	0.21	0.41	0.14	0.34	0.10	0.30	0.14	0.35
Large	0.54	0.50	0.07	0.25	0.06	0.23	0.07	0.25
Province								
San José (Capital)	0.52	0.50	0.49	0.50	0.44	0.50	0.50	0.50
Alajuela	0.11	0.32	0.17	0.37	0.22	0.42	0.16	0.36
Cartago	0.07	0.25	0.08	0.27	0.11	0.32	0.07	0.26
Guanacaste	0.04	0.20	0.06	0.23	0.03	0.17	0.06	0.24
Heredia	0.16	0.37	0.10	0.30	0.12	0.32	0.10	0.30
Limón	0.03	0.18	0.05	0.21	0.04	0.19	0.05	0.21
Puntarenas	0.05	0.23	0.06	0.24	0.04	0.18	0.06	0.25
Observations	9,908		145,921		18,406		127,515	

Note: a/ The statistics are based on 5,010 observations. b/ The statistics are based on 7,562 observations.
Source: Authors' calculations based on data from BCCR and (Alfaro Ureña, Manelici and Vasquez (2018[28]).

The descriptive statistics of the variables measured at the industry level are presented in Table 2.2 for manufacturing and services, between 2008 and 2015. The share of foreign employment (foreign presence) is higher in the manufacturing sector than in services. More than 50% of workers in the manufacturing sector are employed in foreign-owned firms, while in services the figure only reaches 25%. Import competition in the manufacturing sector is around 35%-40% in the period, while in services it is lower. On the other hand, market concentration is lower in the services sector, which suggests that activities are more competitive there. Finally, higher revenue growth is observed in the services sector than in manufacturing.

Table 2.2. Descriptive statistics of sector level variables, 2008-2015

		Two-digit level	Foreign presence (%)		Import competition		Three-digit level	HHI		Revenues gwt rate	
Sector	Year	No. of sectors	Mean	Std. Dev.	Mean	Std. Dev.	No. of sectors	Mean	Std. Dev.	Mean	Std. Dev.
Manufacturing	2008	20	56.6	23.6	0.39	0.16	42	0.34	0.27	0.07	0.15
	2015	20	53.8	24.5	0.35	0.19	41	0.28	0.26	0.03	0.21
Services	2008	43	26.8	23.6	0.08	0.12	99	0.16	0.16	0.14	0.21
	2015	44	27.8	23.4	0.07	0.11	103	0.13	0.16	0.10	0.19

Source: Authors, based on data from BCCR.

Estimation results

Spillovers through foreign presence

Manufacturing specification

The estimation of spillover effects from foreign presence on the productivity of domestic manufacturing firms follows the work by Ruane and Uğur (2005[1]). Panel data models with fixed effects were estimated and Table 2.3 shows the results for the sample of domestic manufacturing firms. *Foreign presence* measured both at the two-digit and three-digit ISIC level is positively correlated with local firms' productivity and the coefficients are statistically significant. At the two-digit industry aggregation, an increase by one percentage point of foreign presence increases local firms' productivity on average by 0.5%, while the increase is 0.2% at the three-digit industry aggregation.

The magnitude of the coefficient estimated at the broader industry level is more than double the one estimated at the three-digit level. A possible explanation is that spillover effects may take place vertically (between-industries), where effects between- and within-industries are allowed, but not horizontally (intra-industries) that only allows for effects in the same sector. Evidence on this idea has been cited in various studies (Javorcik, 2004[21]; Kugler, 2006[36]; Farole and Winkler, 2014[31]). The productivity factors included in the model have the expected sign: capital intensity and the percentage of skilled workers are positively correlated with firm's productivity. This result was also found by Ruane and Uğur (2005[1]) in Ireland; however, there was weak evidence of positive spillovers on the productivity of local manufacturing firms in that country[15].

[15] This paper does not delve into the reasons that prove differences or similarities in the results of both works. However, it is important to keep in mind that both economies differ in characteristics of host countries that literature mentions (Farole and Winkler, 2014[31]; OECD, 2017[10]) as important factors for the absorption of spillovers from FDI, such as the innovation and research eco-system.

Services specification

For estimating spillover effects in the services sector, a baseline specification proposed by Haller (2014[2]) was used. Panel data models with fixed effects were calibrated and Table 2.3 shows the results. The coefficient of *foreign presence* is positively correlated to productivity for both levels of aggregation. At the two-digit sectoral aggregation, an increase of foreign presence by one percentage point increases local firms' productivity on average by 0.3%, while the increase is 0.2% at the three-digit industry aggregation.

Then, a lagged foreign presence variable is included instead of the contemporaneous values to consider that spillover effects may come once FDI firms are well established. The coefficient on lagged *foreign presence* is also positively correlated to productivity for both levels of aggregation; the magnitude at the two-digit industry level is the same as the contemporaneous variable, while an increase of foreign presence by one percentage point in the previous year increases local firms' productivity on average by 0.1% at the three-digit industry aggregation.

The coefficients of control variables included in the model have the expected signs: market concentration is negatively correlated with productivity levels, while higher import competition and revenue growth rates in the industry are positively correlated, but only the last two have significant coefficients. The results differ from the findings of Haller (2014[2]), which reported insignificant or negative effects of foreign presence on Irish domestic services firms; nevertheless, both studies coincide in rejecting the presence of pro-competitive effects from imports on the productivity of domestic services firms.

Table 2.3. Estimated spillovers from foreign presence on local manufacturing and services firms' productivity, 2008-2015

Sector	Manufacturing1				Services2			
Equation	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	two-digit	three-digit	two-digit	three-digit	two-digit	three-digit	two-digit	three-digit
FP t	0.005***	0.002**			0.003***	0.002***		
	[0.001]	[0.001]			[0.001]	[0.001]		
FP t-1			0.003**	0.001			0.003***	0.001**
			[0.001]	[0.001]			[0.001]	[0.000]
Observations	18,406	18,406	17,332	17,332	115,538	115,538	115,538	115,538
Firms	3,299	3,299	3,160	3,160	24,937	24,937	24,937	24,937
R2	0.101	0.101	0.104	0.104	0.007	0.007	0.007	0.007

Note: Standard errors in brackets.
*,**,*** indicates significance at 10%, 5% and 1%, respectively.
All regressions include year dummies and fixed effects.
1/Regressions include the following control variables: ln(K/L) and share of skilled workers
2/Regressions include the following control variables: import competition, HHI, and revenues growth rate
See complete regression results in Annex A1 and A2.
Source: Authors' calculations based on data from BCCR.

One limitation of using aggregated measures is that several factors can be interacting inside or between industries. For example, spillovers can happen if local firms copy technologies or procedures of foreign firms operating in the local market through labour turnover. In addition, a higher presence of foreign firms may deliver more linkages and learning-by-observation, but also more competition for local resources that push local firms to use more efficiently their resources (Javorcik, 2004[21]). As many of these behaviors can happen at the same time, it is difficult to identify clearly from this result how the presence of FDI firms improves the productivity of local firms. Therefore, this work goes further by studying spillover effects through business relationships, using transaction data between local Costa Rican firms and foreign-owned firms operating the country. In addition to the work by Alfaro Ureña, Manelici and Vasquez (2018[28]), this is one of the first research efforts that exploits this type of information for Costa Rica, and which is a novel method internationally.

Spillovers through backward linkages

To identify the spillover effects of FDI presence on local firms' productivity, the PSM method and fixed effects regressions are used. Separate estimation of the effects for manufacturing and services sectors are carried out, as well as for the industries comprising these sectors.

Manufacturing sector

The manufacturing sector sample consists of 1,931 domestic firms, out of which 490 were suppliers of foreign-owned firms at least once between 2009 and 2015. Based on this sample, the PS is estimated using a probit model for the baseline year (the first year that the companies were not suppliers, which is 2008 for about one half of the cases). The PS estimate (see Annex A4, column 1) suggests that the intensity of capital, the percentage of qualified employees and exporting status are positively related to the probability of being a supplier, while micro and small sizes of firms are less likely to be suppliers compared with larger firms. Both suppliers and non-suppliers have firms with a positive probability of being a provider, so the assumption of common support is fulfilled (see Annex A5). Similarity was verified, as the two groups exhibited similar averages for each variable after the matching process (See Annex A6, column 1).

The matching of each supplier firm with the most similar non-supplier results in a sample of 755 firms, 421 treated and 334 control, with all of them being comparable. However, the panel model includes 4,014 observations from 737 unique firms due to the loss of observations by the inclusion of lagged industries variables to control for the effects of competition and growth in the industries. The results can be seen in Table 2.4. The coefficient of being a supplier is positive and statistically significant; it suggests that local supplying firms increase their labour productivity on average by 8% when selling to foreign-owned firms (See Table 2.4, column 1). The lagged supplier coefficient is not significant, which implies that supplying foreign-owned firms one year ago does not seem to impact current productivity (See Table 2.4, column 2). A possible hypothesis to explain this result is that, in order to become suppliers, local companies have to make a series of adjustments that occur at the beginning of the relationship and that may be the cause of a contemporaneous increase in productivity. By the other side, international evidence on transmission channels suggests that productivity increases correspond to demand effects (Farole and Winkler, 2014[31]). However, evaluating the channels through which the increase in productivity takes place goes beyond the scope of this study and is, therefore, a future line of research on the matter.

Additionally, two different measurements of the transaction variable are tested: the share of sales to FDI firms and the dosage. However, the coefficients were not statistically different from zero (See Table 2.4, column 3 and 4). This result suggests that the linear relationship between these variables and the level of productivity of local firms may not be strong. In addition, the marginal effect of an additional year of the supply connection was estimated to be zero. These results seem to suggest that the establishment of a business relationship is what drives the increase in productivity, regardless of the size of the transaction or the number of years the business relationship lasts (See Table 2.4, column 5).

Table 2.4. Estimates of spillovers from backward linkages on local manufacturing firms' productivity, 2008-2015

Equation	(1)	(2)	(3)	(4)	(5)
Method	*PSM+FE*	*PSM+FE*	*PSM+FE*	*PSM+FE*	*PSM+FE*
$Seller_t$	0.080***				0.075***
	[0.021]				[0.023]
$Seller_{t-1}$		0.018			
		[0.022]			
Sales (%)			-0.001		
			[0.002]		
Dosage				0.019	0.005
				[0.012]	[0.014]
Observations	4,014	3,501	4,014	4,014	4,014
Firms	737	718	737	737	737
R^2	0.10	0.09	0.10	0.10	0.10

Note: Standard errors in brackets.
*,**,*** indicates significance at 10%, 5% and 1%, respectively.
All regressions include the following control variables: ln(K/L), share of skilled workers, exporter, micro size, small size, import competition, HHI and revenues growth rate, year dummies and fixed effects.
See complete regression results in the Annex A3.
Source: Authors' calculations based on data from BCCR and Alfaro Ureña, Manelici and Vasquez (2018[28]).

Manufacturing industries

The manufacturing sector includes a set of productive activities for which there could be variability in the coefficient that relates being a supplier of FDI firms with the productivity of local firms. In addition, some activities are more exposed to exporting or have more skilled workers. Although the previous estimates control for these and other confounding factors, the result obtained is an average across all manufacturing activities, so it is pertinent to check whether the effect differs across activities.[16]

In this case, the manufacturing sector is divided into four sub-sectors: a) food industry; b) rubber, plastic, glass, and metal products; c) medical devices, electronics, machinery and equipment; and d) other manufacturing activities. For each industry, estimations are carried out using three different samples: sample 1 includes all firms; sample 2 includes only firms with a baseline; and, sample 3 is the matching sample. The latter attempts to correct for the possible existence of a self-selection bias. Despite the possible presence of such bias in the estimation using the other two samples, they are shown for comparison reasons as a robustness test.

[16] There is a methodology, called "mixed effects models", which is an alternative way to address this issue, but the estimation by classical statistical methods only allows the estimates of the fixed or shared part of the coefficient in the sectors and not the specific effect for each of them.

The results are shown in Table 2.5 and they vary across industries. The coefficient estimated using PSM and fixed effects in the industries of rubber, plastic, glass, and metal manufactures is positive and significant, indicating that the productivity of local firms that do business with FDI firms operating in Costa Rica is 12.6% bigger. This result is consistent across all of the three samples used.

There is also evidence of positive spillover effects on the productivity of local firms in "other" manufacturing activities that sell to FDI firms, showing on average a magnitude that is 16% bigger. This group of products includes, for example, textiles and apparel, leather and products thereof; wood and paper products; chemicals; and furniture. The coefficient increased when using the sample that compares firms that are more similar. In contrast, local firms in the food and high-tech manufacturing activities do not seem to have higher levels of productivity resulting from their business relationships with foreign-owned firms. This result is robust across all of the three samples used. Further research is needed to understand why the effect differs across industries. For example, Chen, Kokko and Tingvall (2011[37]) found that Chinese industries with higher absorptive capacity and/or higher efficiency are better equipped to take advantage of spillovers from foreign firms.

Table 2.5. Results by sector: estimates of spillovers from backward linkages on local manufacturing firms' productivity, 2008-15

Sub-sector	Detail	Sample 1 FE	Sample 2 FE	Sample 3 PSM+FE
Food Industry[1]	Coefficient	0.040	0.019	0.020
	Standard Error	[0.026]	[0.030]	[0.040]
	Observations	6,321	4,708	1,179
Rubber, plastic, glass & metal industry	Coefficient	0.096***	0.126***	0.126**
	Standard Error	[0.032]	[0.047]	[0.058]
	Observations	2,316	796	620
Medical devices, electronic, machinery & equipment	Coefficient	0.009	-0.065	-0.003
	Standard Error	[0.060]	[0.098]	[0.097]
	Observations	699	309	189
Other Manufacturing[1]	Coefficient	0.122***	0.135***	0.159***
	Standard Error	[0.019]	[0.031]	[0.037]
	Observations	7,996	3,494	1,605

Note: *,**,*** indicates significance at 10%, 5% and 1%, respectively.

All regressions include the following control variables: ln(K/L), skilled workers, exporter, micro size, small size, and year dummies.

1/In addition, regressions include the following control variables: import competition, HHI, and revenues growth rate

Source: Authors' calculations based on data from BCCR.

Services sector

The services sample consists of 19,794 domestic firms out of which 3,729 are suppliers of FDI firms at least once between 2009 and 2015. Based on this sample, the PS is estimated using a probit model for the baseline year (the first year that the firms were not suppliers, which was 2008 in 37% of the cases and around 9% for each of the other years of the period considered). The PS estimate (see Annex A4, column 2) suggests that the intensity of capital, the percentage of qualified employees and being located in San José are positively related to the probability of being a supplier, while micro and small firms are less likely to be suppliers than larger firms. Both suppliers and non-suppliers have firms with a positive probability of being a provider, so the assumption of common support is fulfilled (see Annex A7). Again, the treatment and control group created from the matching procedure have similar averages for each variable (See Annex 6, column 2).

The matching of each supplier firm with the most similar non-supplier results in a sample of 6,805 businesses, out of which 3,734 are treated and 3,076 are controls, all of them with common support. However, the panel model includes 32,458 observations from 6,471 unique firms due to the loss of observations in the inclusion of lagged sector variables to control for the effects of competition and growth in the sectors. The results are shown in Table 2.6. The coefficient associated with being a supplier is positive and statistically significant. This suggests that the labour productivity of local firms that sell to foreign-owned ones is on average 6.4% higher than the productivity of similar local firms that do not supply foreign firms (See Table 2.6, column 1). The coefficient of the lagged variable is also significant, which implies that supplying foreign-owned firms one year ago pushes local firm’s current productivity upwards by 3.1% (See Table 2.6, column 2).

In addition, different measurements of the variable of interest are tested (the share of sales to FDI firms and the cumulative number of years that a local firm supplied a foreign firm), although there is evidence of a rather modest effect for both. The results suggest that, other factors equal, for a 1% increase of local services firms’ sales to foreign-owned firms, the productivity of the former increases by 0.1%. The continuation of the relationship for an additional year seems to increase productivity by 1.1%, but this effect becomes insignificant when the dummy seller variable (capturing whether or not the local firm supplies a foreign firm in any year) is included in the regression, which indicates that there is no marginal effect of an additional year on the supply relationship. The results seem to suggest that the establishment of the relationship is what is generating the increase in productivity, regardless of the size of the transaction or the number of years the relationship lasts.

Table 2.6. Estimates of spillovers from backwards linkages on local service firms' productivity, 2008-2015

Equation	(1)	(2)	(3)	(5)	(6)
Method	*PSM+FE*	*PSM+FE*	*PSM+FE*	*PSM+FE*	*PSM+FE*
Seller	0.064***				0.065***
	[0.008]				[0.008]
$Seller_{-1}$		0.031***			
		[0.008]			
Sales(%)			0.001*		
			[0.001]		
Dosage				0.011**	-0.001
				[0.004]	[0.005]
Observations	32,458	28,106	32,458	32,458	32,458
Firms	6,471	6,199	6,471	6,471	6,471
R^2	0.102	0.102	0.099	0.099	0.102

Note: Standard errors in brackets.
*,**,*** indicates significance at 10%, 5% and 1%, respectively.
All regressions include the following control variables: ln(K/L), skilled workers, micro size, small size, import competition, HHI and revenues growth rate, year dummies and fixed effects.
See complete regression results in the Annex A8.
Source: Authors, based on data from BCCR.

Service industries

This section explores the effects of spillovers separately in the following services industries: a) wholesale, retail trade & transportation; b) informatics, information, and communications; c) business services; and d) other services. As with the manufacturing industries, for each industry, estimations are carried out using three different samples: sample 1 includes all firms; sample 2 includes only firms with a baseline; and, sample 3 is the matching sample. As applied on the case of manufacturing industries to correct for the possible existence of a self-selection bias.

The results are shown in Table 2.7 and they vary across industries. Estimations obtained by using the matching sample show that the productivity of local business services firms that supply FDI firms is estimated to be, on average, 8.7% higher than similar local firms that do not supply foreign firms.[17] The estimations based on samples 1 and 2 yielded positive and significant values for this coefficient, but the magnitude was smaller than when using the matching sample.

In turn, local firms in the wholesale, retail trade & transportation industry that sell to foreign-owned firms have, on average, a level of productivity that is 5.7% higher than similar local firms that do not sell to foreign firms. Local firms of the other service industries (encompassing construction activities, accommodation and food services, education, human health and social work) that sell to FDI firms are estimated to have a level of productivity that is 6% larger than non-suppliers. For both industries, results

[17] This sub-sector includes professional, scientific and technical activities, as well as administrative and support service activities.

obtained using the matching sample are nearly one percentage point smaller than those from using either sample 1 or 2.

These results are robust in terms of the sign and statistical significance across the three samples used in the estimation, with the exception of the informatics, information & communications industry. The estimates for this industry using samples 1 and 2 are positive and significant, but when the matching sample is used, the estimate is halved and is no longer statistically significant. Nevertheless, in order to confirm that this lack of significance does not respond to an issue of sample size, a larger sample comprising the four closest neighbors for each supplier is used. The result of this additional estimation confirms the original finding.

Table 2.7. Results by industry: estimates of spillovers from backward linkages on local services firms' productivity, 2008-15

Sub-sector	Detail	Sample 1 FE	Sample 2 FE	Sample 3 PSM+FE
Wholesale, retail trade & transportation	Coefficient	0.065***	0.054***	0.057***
	Standard Error	[0.008]	[0.010]	[0.010]
	Observations	57,160	37,577	15,253
Informatics, information & communication	Coefficient	0.184***	0.115**	0.071
	Standard Error	[0.040]	[0.046]	[0.045]
	Observations	3,169	1,626	742
Business services	Coefficient	0.078***	0.083***	0.087***
	Standard Error	[0.015]	[0.020]	[0.020]
	Observations	19,343	12,083	6,078
Other services	Coefficient	0.071***	0.055***	0.061***
	Standard Error	[0.011]	[0.014]	[0.014]
	Observations	35,866	27,617	9,983

Note: *,**,*** indicates significance at 10%, 5% and 1%, respectively.
All regressions include the following control variables: ln(K/L), skilled workers, micro size, small size, import competition, HHI and revenues growth rate, year dummies and fixed effects.
Source: Authors' calculations based on data from BCCR.

Robustness check

To assess the robustness of the results for the manufacturing and the services sectors, the revenue per worker measure of labour productivity (the dependent variable in the regressions) were replaced by value-added per worker. The results from this alternative version of the estimation fully support the previous findings on the existence of positive and statistically significant spillover effects on the productivity of local Costa Rican firms. Moreover, the magnitudes of the productivity spillovers are larger when value-added per worker as the dependent variable.

In the manufacturing sector, local firms that are suppliers of foreign-owned firms have a level of productivity that is on average 12.3% larger than non-suppliers, four percentage points larger than the one obtained in the original estimation using revenues. In the services sector, the increase in the productivity of local firms is 8.3%, about two percentage points larger than the one from the original estimation using revenues (see results in Annex A9). However, as Haller (2014[2]) points out, the fact that firms do not produce output in terms of real value-added may create an issue when measuring productivity using value-added. For this specific study, another issue that motivates to prefer the use of revenue for measuring productivity is the existence of missing values for value-added, due to lack of information on costs of production for several firms (as noted in Chapter 4).

Limitations

The criteria used to define the treated group may be inaccurate for firms that were suppliers before the first year of the period considered, then suspended their sales at some point in time and resumed them in a year after 2008. For these cases, the determinants of being a supplier would be affected by the treatment, which would violate the assumption of unconfoundedness. Then, the matching will look for non-supplying firms with a high probability of being a supplier and, possibly, with high levels of productivity, which would generate a downward-biased estimator of the productivity spillover stemming from being a supplier. One out of every six local supplying firms (16.8% to be precise) was found to resume its activity as a supplier of FDI firms over the 2009-2015 period. If a similar incidence is expected to happen for the years before 2008, the possible bias of the spillover estimates may be a relevant issue.

However, a new stream of work in progress by Alfaro Ureña, Manelici and Vasquez (2018[28]) identifies the first year of a transactions between local firms and the foreign-owned ones. The authors are measuring the changes in the productivity, size, and exposure to the foreign market of local firms with an event study design, in which the event is the first interaction with a foreign firm. Preliminary findings from this research suggest that local firms expand and adjust their production process after becoming a first-time supplier to a foreign firm. In addition, they find evidence that these firms experience sizable and persistent productivity gains, which lends support to the findings of our study. The authors also find evidence of gains for the other clients of the foreign firms, which is suggestive of spillovers to other firms.

Finally, the structure of the unbalanced panel data used and the variability across firms in the first year of the business relationship means that the baseline corresponds to different moments in time across firms. Therefore, the estimated probability of being a supplier does not correspond to the same year for all companies. Approximately, 40% of the companies have a baseline in 2008, a bit less than 9% in each year between 2009 and 2014, and 7% in 2015. If the probabilities of being a supplier change over time, there could be a bias due to the matching of different units in the same moment in time.

Conclusions

Costa Rica is an economy that has been able to combine its foreign trade policy with a successful FDI attraction policy, which together have led to a deep and rapid structural transformation of the economy. However, some sectors have not been able to benefit much from such change. In fact, Costa Rican local firms are characterized by two different levels of performance, as some of them are fully integrated in international markets and the other do not have the capabilities needed for such integration.

As a general fact from data, it is confirmed that foreign-owned firms operating in Costa Rica are different from local firms. The former has higher productivity than the latter. FDI firms also have a higher share of qualified employees, are larger, and have greater participation in exporting activities. The prevalence of foreign firms is greater in the manufacturing sector than the services sector. FDI manufacturing firms account for nearly half of formal employment in the manufacturing sector, compared with only one quarter in the services sector.

This study first applied an industry-level measure of the presence of foreign-owned firms to examine whether spillovers from foreign investment has a positive impact on the productivity of local firms. We found evidence that the presence of foreign firms is positively correlated with the productivity of local Costa Rican firms in both the manufacturing and the services sectors. This contrasts Ruane and Uğur (2005[1]) and Haller (2014[2]), which found insignificant or even negative spillover effects from foreign-owned firms to local Irish firms in the manufacturing and services sectors respectively. We also found that a lagged measure of foreign presence was positively correlated to the current productivity of local firms, but that the magnitude was smaller than the contemporaneous effect. Also, using a more aggregated measure of foreign presence gives a larger estimate of spillover effects. One possible hypothesis to explain this is that spillover effects may take place vertically (between-industries) as well as horizontally (intra-industries).

We then applied a more novel approach, which involved measuring the direct supplier relationship from local to foreign firms using data on firm-to-firm transactions. Our analysis of spillovers through these backward linkages revealed a positive and statistically significant correlation between the existence of business relationships with FDI firms and the productivity of their domestic suppliers, using propensity score matching techniques to mitigate self-selection bias. In the **manufacturing sector**, the local supplying firms have, on average, **8% higher labour productivity** than those that do not have business relations with foreign-owned firms. However, being a provider of foreign-owned firms the year before does not seem to affect current productivity. A possible hypothesis to explain this result is that, in order to become suppliers, local companies have to make a series of adjustments that occur at the beginning of the relationship and that may be the cause of an increase in productivity. In the **services sector**, local firms that are suppliers of foreign-owned firms have, on average, **6.4% higher labour productivity** than those that do not have business relations with foreign-owned firms. However, in this case being a supplier of FDI firms the year before was found to increase current productivity, but in a smaller magnitude than the contemporaneous effect. These results suggest that the establishment of the business relationship with FDI firms is what is driving the increase in productivity, regardless of the size of transactions or the number of years the relationship lasts.

The results vary across industries, both in the manufacturing and services sectors. The estimated productivity spillover effect is positive for local firms in the industries of rubber, plastic, glass, metal, and "other" manufacturing industries. Food industry local firms and those in high-tech manufacturing do not seem to increase their productivity as a result of being providers of FDI firms. Local business services firms seem to have the strongest productivity spillover effect among services firms. For the activities of wholesale, retail trade & transportation, and other services, there is a positive productivity spillover effect from sales to foreign-owned firms. However, local firms in the informatics, information & communications industry do not seem to enjoy productivity spillover effects from such transactions.

In addition to the variability of the effects across sub-sectors, the heterogeneity of firms' characteristics may play an important role in the observance of spillover effects from FDI firms (Crescenzi, Gagliardi and Iammarino, 2015[38]). For example, firms that are more integrated in foreign trade or that bear a higher level of skilled workers may have a different level of absorption capacity than other firms. Although this hypothesis was not directly tested in this work, the results by splitting the analysis in sub-sectors suggests that high-tech sectors, characterized for being exporters and hiring highly skilled workers, have less room to benefit from FDI spillovers.

The main finding of this work is that FDI firms have the capacity to generate spillovers on local firms' productivity. However, taking advantage of it may depend at least on two factors: the links between the local economy with FDI firms, and the local firm characteristics. Therefore, it seems to be crucial identify those characteristics of local firms that allows to take advantages from linkages the most. A non-negligible number of firms are related to foreign-owned firms, but Costa Rica's dilemma is to make this foreign-related apparatus expand to the rest of the economy. This reaffirms the need to continue strengthening FDI attraction strategy, and the programs for local firms to link.

A robustness check was conducted by using value-added per worker instead of revenue when computing the dependent variable of the regressions. The results confirmed in all cases the original results, thus providing stronger grounds to document the existence of positive and statistically significant productivity spillovers from FDI firms operating in Costa Rica to the domestic firms. The estimated magnitudes of the spillover effect were even bigger when using value-added, but the fact that firms do not produce output in terms of real value-added and the existence of missing records for the value-added variable in the sample, led the authors to prefer the use of revenue for computing the dependent variable in the regressions.

As our analysis is based on assumptions about the timing of when the business relationships with foreign-owned firms started, further work is needed to understand better the mechanisms through which the presence of FDI positively affects domestic firms. Some additional work could be explored to greater depth on identifying specific areas of industries and types of firms that most benefit from FDI, but also unbundling the reasons behind this phenomenon. For example, this could involve investigating whether firms that are closer to the technological frontier or that have better management practices are more likely to benefit from spillovers. Understanding these pre-conditions for benefiting from spillovers could also provide further insights for the design of firm-assistance policies.

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Annex A.

Annex A1

Table A1. Estimates of spillovers from foreign presence on manufacturing firms' productivity, 2008-2015

Equation	(1)	(2)	(3)	(4)
	two-digit	three-digit	two-digit	three-digit
FP $_t$	0.005***	0.002**		
	[0.001]	[0.001]		
FP $_{t-1}$			0.003**	0.001
			[0.001]	[0.001]
ln(K/L)	0.184***	0.184***	0.184***	0.185***
	[0.011]	[0.011]	[0.012]	[0.012]
Skilled workers (%)	0.001***	0.001***	0.001***	0.001***
	[0.000]	[0.000]	[0.000]	[0.000]
Constant	13.786***	13.906***	13.821***	13.918***
	[0.193]	[0.187]	[0.204]	[0.197]
Observations	18,406	18,406	17,332	17,332
Firms	3,299	3,299	3,160	3,160
R^2	0.101	0.101	0.104	0.104

Note: Standard errors in brackets.
*,**,*** indicates significance at 10%, 5% and 1%, respectively.
All regressions include year dummies and fixed effects.
Source: Authors' calculations based on data from BCCR and Alfaro Ureña, Manelici and Vasquez (2018[28]).

Annex A2

Table A2. Estimates of spillovers from foreign presence on services firms' productivity, 2008-2015

Equation	(1)	(2)	(3)	(4)
	two-digit	three-digit	two-digit	three-digit
FP_t	0.003***	0.002***		
	[0.001]	[0.001]		
FP_{t-1}			0.003***	0.001**
			[0.001]	[0.000]
$Imp.Comp_{t-1}$	0.099	0.040	0.152	0.030
	[0.104]	[0.105]	[0.106]	[0.105]
HHI	-0.110**	-0.212***	-0.047	-0.050
	[0.043]	[0.079]	[0.041]	[0.040]
Revenues gwt $rate_{t-1}$	0.048***	0.042***	0.033**	0.038**
	[0.015]	[0.015]	[0.015]	[0.016]
Constant	17.027***	17.066***	17.017***	17.081***
	[0.014]	[0.014]	[0.017]	[0.013]
Observations	115,538	115,538	115,538	115,538
Firms	24,937	24,937	24,937	24,937
R-squared	0.007	0.007	0.007	0.007

Note: Standard errors in brackets.
*,**,*** indicates significance at 10%, 5% and 1%, respectively.
All regressions include year dummies and fixed effects.
Source: Authors based on data from BCCR.

Annex A3

Table A3. Estimates of spillovers from backward linkages on manufacturing firms' productivity, 2008-2015

Equation	(1)	(2)	(3)	(4)	(5)
Method	PSM+FE	PSM+FE	PSM+FE	PSM+FE	PSM+FE
$Seller_t$	0.080***				0.075***
	[0.021]				[0.023]
$Seller_{t-1}$		0.018			
		[0.022]			
Sales			-0.001		
			[0.002]		
Dosage				0.019	0.005
				[0.012]	[0.014]
ln(K/L)	0.176***	0.171***	0.177***	0.176***	0.176***
	[0.028]	[0.034]	[0.029]	[0.028]	[0.028]
Skilled workers (%)	0.000	0.000	0.000	0.000	0.000
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Exporter	0.024	0.036	0.030	0.023	0.023
	[0.073]	[0.071]	[0.073]	[0.073]	[0.072]
Micro	-0.109	-0.094	-0.121*	-0.111	-0.107
	[0.069]	[0.070]	[0.070]	[0.069]	[0.069]
Small	-0.016	-0.031	-0.023	-0.015	-0.014
	[0.060]	[0.059]	[0.061]	[0.060]	[0.060]
$Imp.Comp_{t-1}$	0.125	0.023	0.118	0.135	0.130
	[0.265]	[0.240]	[0.266]	[0.266]	[0.265]
HHI	-0.329	-0.375	-0.377	-0.340	-0.323
	[0.338]	[0.376]	[0.338]	[0.339]	[0.340]
Revenues $gwtrate_{t-1}$	0.084	0.044	0.073	0.079	0.085
	[0.060]	[0.060]	[0.061]	[0.060]	[0.060]
Constant	14.106***	14.257***	14.134***	14.110***	14.101***
	[0.479]	[0.564]	[0.485]	[0.476]	[0.476]
Observations	4,014	3,501	4,014	4,014	4,014
Firms	737	718	737	737	737
R^2	0.100	0.087	0.095	0.097	0.100

Note: Standard errors in brackets.
*,**,*** indicates significance at 10%, 5% and 1%, respectively.
All regressions include year dummies and fixed effects.
Source: Authors' caluations based on data from BCCR and Alfaro Ureña, Manelici and Vasquez (2018[28]).

Annex A4

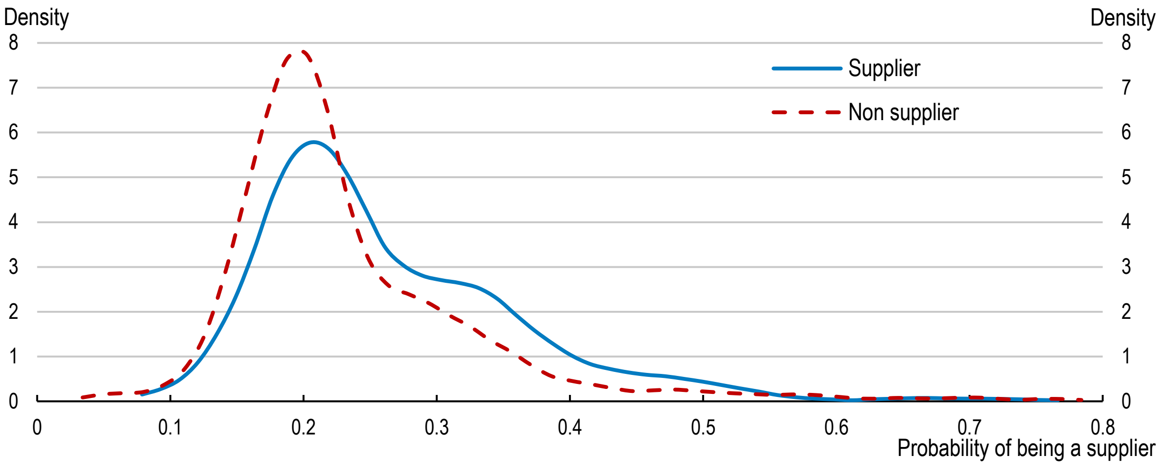
Table A4. Results of probit model for manufacturing and services sectors, 2008a

Variables	(1) Manufacturing		(2) Services	
ln(K/L)	0.098	***	0.065	***
Skilled workers (%)	0.004	***	0.003	***
Exporter	0.296	**	-	
San José province	-0.042		0.066	***
Micro firm	-0.824	***	-0.536	***
Small firm	-0.452	***	-0.302	***
Constant	-1.560	***	-1.615	***
Observations	1,931		19,799	
Treated	490		3,734	
Untreated	1,441		16,065	

Note: a/ For firms registered in dataset after 2008, the baseline correspond to the first year that the firm did not supply to foreign-owned firms.
Source: Authors based on BCCR database.

Annex A5

Figure A5. Common support on the probability of manufacturing firms of being supplier



Source: Authors based on BCCR database.

Annex A6

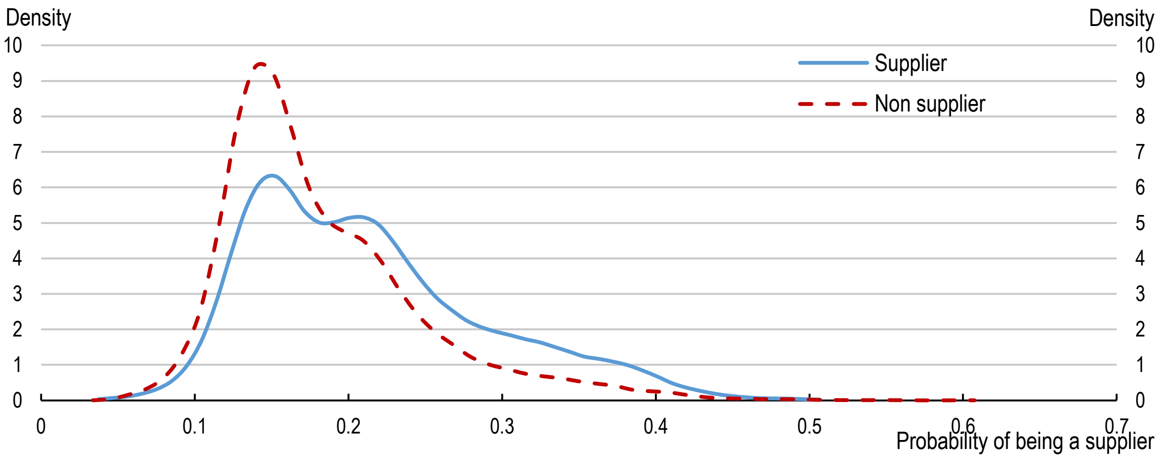
Table A6. Balances before and after matching for manufacturing and services sectors, 2008a

Variables	Sample	Difference (1) Manufacturing		Difference (2) Services	
ln(K/L)	Before matching	0.505	***	0.381	***
	After matching	-0.072		0.062	
Skilled workers (%)	Before matching	8.120	***	7.610	***
	After matching	-0.171		0.040	
Exporter	Before matching	0.057	***	-	
	After matching	-0.585		-	
San José province	Before matching	-0.008		0.042	***
	After matching	-0.024		0.008	
Micro firm	Before matching	-0.187	***	-0.148	***
	After matching	0.000		0.014	
Small firm	Before matching	0.101	***	0.061	***
	After matching	-0.007		-0.009	

Note: authors' calculations based on BCCR database.
Source: authors' calculations based on BCCR database.

Annex A7

Figure A7. Common support on the probability of manufacturing firms of being supplier



Source: Authors based on BCCR database.

Annex A8

Table A8. Estimates of spillovers from backward linkages on services firms' productivity, 2008-2015

Equation	(1)	(2)	(3)	(4)	(5)
Method	PSM+FE	PSM+FE	PSM+FE	PSM+FE	PSM+FE
$Seller_t$	0.064***				0.065***
	[0.008]				[0.008]
$Seller_{t-1}$		0.031***			
		[0.008]			
Sales			0.001*		
			[0.001]		
Dosage				0.011**	-0.001
				[0.004]	[0.005]
ln(K/L)	0.169***	0.169***	0.170***	0.170***	0.169***
	[0.009]	[0.009]	[0.009]	[0.009]	[0.009]
Skilled workers (%)	0.001***	0.001***	0.001***	0.001***	0.001***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Micro	0.187***	0.201***	0.181***	0.183***	0.187***
	[0.025]	[0.026]	[0.025]	[0.025]	[0.025]
Small	0.091***	0.102***	0.088***	0.090***	0.091***
	[0.019]	[0.019]	[0.019]	[0.019]	[0.019]
Imp. $Comp_{t-1}$	0.077	0.094	0.058	0.067	0.076
	[0.190]	[0.187]	[0.190]	[0.190]	[0.190]
HHI	0.033	0.002	0.035	0.034	0.033
	[0.074]	[0.063]	[0.075]	[0.074]	[0.074]
Revenues growth $rate_{t-1}$	0.035	0.086***	0.033	0.034	0.034
	[0.036]	[0.023]	[0.036]	[0.036]	[0.036]
Constant	14.139***	14.171***	14.157***	14.142***	14.141***
	[0.151]	[0.150]	[0.151]	[0.151]	[0.151]
Observations	32,458	28,106	32,458	32,458	32,458
Firms	6,471	6,199	6,471	6,471	6,471
R^2	0.102	0.102	0.099	0.099	0.102

Note: Standard errors in brackets.
*,**,*** indicates significance at 10%, 5% and 1%, respectively.
All regressions include year dummies and fixed effects.
Source: Authors' calculations based on data from BCCR and Alfaro Ureña, Manelici and Vasquez (2018[28]).

Annex A9

Table A9. Estimates of spillovers from backward linkages on services and manufacturing firms' productivity, 2008-2015

Sector	Manufacturing		Services	
Equation	(1)	(2)	(3)	(4)
Dependent variable	ln(Y/L)	ln(VA/L)	ln(Y/L)	ln(VA/L)
$Seller_t$	0.080***	0.123***	0.064***	0.083***
	[0.021]	[0.040]	[0.008]	[0.015]
Exporter	0.024	0.127	-	-
	[0.073]	[0.106]	-	-
ln(K/L)	0.176***	0.228***	0.169***	0.249***
	[0.028]	[0.042]	[0.009]	[0.015]
Skilled workers (%)	0.000	0.001	0.001***	0.002***
	[0.001]	[0.001]	[0.000]	[0.000]
Micro firm	-0.109	-0.194	0.187***	0.197***
	[0.069]	[0.156]	[0.025]	[0.045]
Small firm	-0.016	0.047	0.091***	0.075**
	[0.060]	[0.134]	[0.019]	[0.035]
Imp. $Comp_{t-1}$	0.125	0.904	0.077	0.040
	[0.265]	[0.551]	[0.190]	[0.370]
HHI	-0.329	-0.892	0.033	-0.072
	[0.338]	[0.617]	[0.074]	[0.147]
Revenues gwt $rate_{t-1}$	0.084	0.124	0.035	0.034
	[0.060]	[0.117]	[0.036]	[0.054]
Constant	14.106***	12.023***	14.139***	11.271***
	[0.479]	[0.704]	[0.151]	[0.250]
Observations	4,014	3,963	32,458	32,311
Firms	737	736	6,471	6,430
R^2	0.100	0.074	0.102	0.053

Note: Standard errors in brackets.
*,**,*** indicates significance at 10%, 5% and 1%, respectively.
All regressions include year dummies and fixed effects.
Source: Authors' calculations based on data from BCCR and Alfaro Ureña, Manelici and Vasquez (2018[28]).

Annex A10

Table A10. Correlation coefficients

Variables	ln(Y/L)	Sales	Dosage	ln(K/L)	Share skilled labour	Imp. $Comp_{t-1}$	HHI	Revenues gwt $rate_{t-1}$
ln(Y/L)	1.000							
Sales	0.030	1.000						
Dosage	0.069	0.555	1.000					
ln(K/L)	0.424	-0.021	0.060	1.000				
Share skilled labour	0.117	0.072	0.130	0.133	1.000			
Imp. $Comp_{t-1}$	0.112	0.052	0.105	0.075	0.000	1.000		
HHI	0.039	0.035	0.040	0.004	0.008	0.246	1.000	
Revenues gwt $rate_{t-1}$	-0.009	-0.005	-0.076	-0.053	0.013	-0.135	0.027	1.000

Source: Authors based on data from BCCR and Alfaro Ureña, Manelici and Vasquez (2018[28]).

Chapter 3. The Road to Development: Identifying upscaling opportunities for Costa Rica

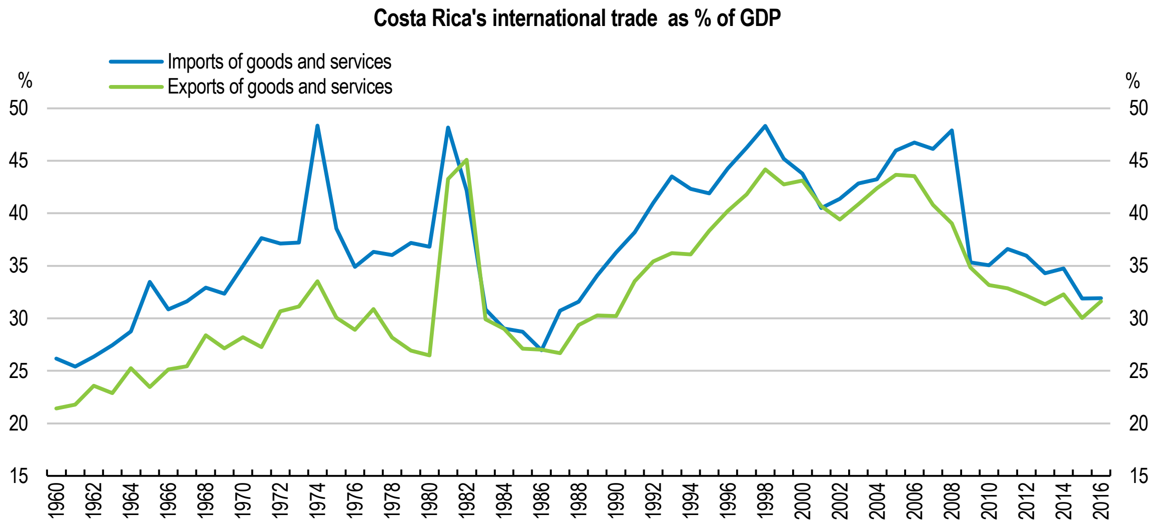
By Sónia Araújo, Alex Linares and Thomas Chalaux

Costa Rica has undergone a remarkable process of structural transformation since it embraced trade liberalisation during the 1980s. Open trade and foreign direct investment inflows have underpinned the transition from a rural and agricultural-based economy to one which is increasingly specialised in medium- and high-technology products and services. This paper combines the Theory of Economic Complexity of (Hidalgo and Hausmann, 2009[1]) with measures of "revealed relatedness" developed by Lebre de Freitas et al. (2015[2]) to provide an empirical assessment of the level of complexity of Costa Rica's export basket and identify possible opportunities for Costa Rica to expand and upscale its production capabilities. The results show that most of Costa Rica's upscale opportunities lie in the Machinery-Electrical and Chemicals-Plastics-Rubbers sectors. When comparing upscaling opportunities across Latin American countries, Mexico clearly stands out as all identified products are very highly complex. Like Costa Rica, Argentina, Brazil and Colombia have most of their upscaling opportunities in very high complexity products. By contrast, Costa Rica's neighbours, as well as Peru and Chile, show fewer possibilities to specialise into products of high-embedded capabilities.

Introduction

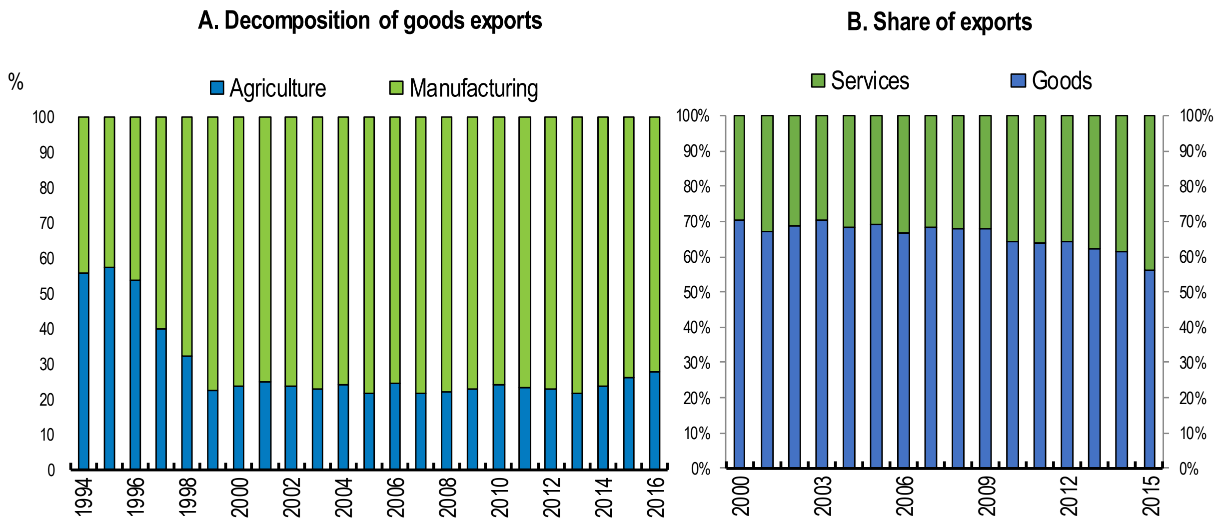
In 1950 Costa Rica's export basket was dependent on four traditional products: 90% of the country's export revenues relied on the production of coffee, banana, sugar and meat. The country's integration in the Central American Common Market (CACM) in 1963 underpinned a structural shift towards a more diversified product mix which included industrial products (Rodríguez-Clare, Sáenz and Trejos, 2002[3]). However, the abandonment of import substitution policies in favour of an open trade and foreign direct investment growth model has allowed for a sustained expansion of production since the mid-1980s (Rodríguez-Clare, 2001[4]). Notwithstanding a recent drop in trade openness measured by the ratio of exports and imports to GDP in the aftermath of the financial crisis, Costa Rica has become increasingly open, moving away from a rural agricultural-based economy to one with a more diversified structure (Figure 3.1). Over time, the share of manufacturing exports and more recently, of services, has increased (Figure 3.2). Costa Rica now enjoys a comparative advantage in a number of high-tech sophisticated manufacturing and knowledge-intensive service industries.

Figure 3.1. Costa Rica is an open economy



Source: World Bank - World Development Indicators retrieved in August 2017.

Figure 3.2. Costa Rica's export structure has shifted towards manufactured goods and services



Source: OECD Bilateral Trade in Goods by Industry and End-use database (BTDIxE), ISIC Rev.4 & OECD Trade in Services database, Extended Balance of Payments Services classification (EBOPS 2010).

This paper aims to provide an assessment of the level of sophistication of Costa Rica's production structure and evaluates the country's possibilities to "upscale", defined as moving towards producing more complex products. The analysis rests on the rapidly growing literature that emerged around the theory of economic complexity, according to which a country's development path is determined by its capacity to accumulate the capabilities that are required to produce more sophisticated products, i.e., products that are associated with higher levels of productivity (Hidalgo et al., 2007[5]; Hidalgo and Hausmann, 2009[1]; Hausmann and Hidalgo, 2011[6]). In turn, capabilities are defined as the broad set of skills, physical capital and institutions that are needed to produce a product. Country differences in economic performance are then explained by different abilities in accumulating capabilities that are associated with more sophisticated products, associated with higher productivity levels (Hidalgo and Hausmann, 2009[1]; Hausmann and Hidalgo, 2011[6]).

The framework of Economic Complexity, and related research, has put structural transformation back at the forefront of understanding economic growth and there are well-established empirical results supporting this: the economic performance of a country depends on the specific basket of products in which it specialises (Hausmann, Hwang and Rodrik, 2007[7]). Countries specialising in more complex goods grow faster (Hidalgo and Hausmann, 2009[1]; Hausmann and Hidalgo, 2011[6]) and the structural transformation process is dependent on which industries the country is currently specialised in (Hausmann and Klinger, 2006[8]; Hausmann and Klinger, 2007[9]; Hidalgo et al., 2007[5]; Hausmann and Hidalgo, 2011[6]). Overall, differences in the ability of countries to upgrade their production and diversify into complex goods appear to explain why some prosper while others remain poor (McMillan and Rodrik, 2011[10]).

These concepts are operationalised by the so-called "product space" developed by Hidalgo et al. (2007[5]), which provides a network representation of all products exported in the world, where products are linked based on the similarity of their required capabilities. By producing a particular basket of goods, a country reveals abundance in particular endowments or has developed specific capabilities, such as technical knowledge, infrastructure, producer services, access to markets, and specific regulatory requirements. These endowments and capabilities, referred to by Hidalgo and Hausmann (2009[1]) as knowledge embedded in products, in turn, may be more favourable or more easily adapted to start producing some goods than others. A measure of "proximity" or "relatedness" assesses how valuable a country's experience in producing a particular good is to developing a comparative advantage in other goods, and therefore supportive of a process of structural transformation. In practice, "relatedness" measures the likelihood of a country having comparative advantages in both the existing good as well as a specified new good. The likelihood of a country developing a comparative advantage in a new product is captured by "density" or "distance", a synthetic measure that summarises the proximity or relatedness of that new product with all the products in which the country already has a comparative advantage. Hidalgo et al. (2007[5]), Hidalgo and Hausmann (2009[1]) and Hausmann and Hidalgo (2011[6]) find that "density" is highly significant in predicting a country's future specialisation patterns, which can be interpreted as a tendency to move towards related goods as countries change their export mix, rather than to goods that are less related to the current structure.

This paper adapts the Revealed Relatedness Indexes (RRIs) developed by Lebre de Freitas et al. (2015[2]) to assess the level of complexity of Costa Rica's exports and identify the set of products into which Costa Rica may upscale into. The paper also benchmarks Costa Rica's upscaling opportunities and trade performance with those of other larger and neighbouring Latin American economies.

Revealed Relatedness Indexes are an alternative to the method of reflections (see Section 2) developed by Hidalgo and Hausmann (2009[1]) and Hausmann and Klinger (2006[8]; 2007[9]) and possess several interesting characteristics. First, RRIs are subject to statistical tests to compare probabilities, filtering only statistically significant relationships between pairs of products. The RRI calculated for each pair of products is defined as the increment in the probability of a country having a revealed comparative advantage (RCA) in one product due to the fact that it has an RCA in the other element of the pair. Since a large proportion of the estimated RRIs are found to be not statistically significant, it is plausible that the method developed in Hausmann and Klinger (2006[8]; 2007[9]), based on the computation of non-parametric conditional probabilities, is overestimating the available options a country has to upgrade its production structure.

Second, the RRI approach allows levels of relatedness between each product pair to be either negative or positive, whereas the Hausmann's framework bounds the indexes of product relatedness to be strictly non-negative. Allowing for negative relationships between two products captures the fact that the capabilities necessary for the production of one product are not favourable for the production of another and is, in this sense, more realistic.

A third novelty is that the RRIs method does not impose symmetry in the matrix of product relatedness, as is the case in the Hausmann's framework. Imposing a symmetric matrix was a solution to overcome the limitation of computing conditional probabilities when only a few countries have comparative advantages in one of the products. In our framework, cases where only a few countries have RCAs in both products result in non-significant estimates and the respective RRIs are set equal to zero. Working with a non-symmetric matrix is also more realistic, as it allows for the possibility that an RRI between product A and product B could be different than one associated from product B to product A. In practical terms, non-symmetry allows for the possibility that a revealed comparative advantage in product A may be associated with upscaling opportunities into product B while the converse may not hold.

A novelty in this paper is that we modify the RRI methodology developed by Lebre de Freitas et al. (2015[2]) and use product and country economic complexity indicators, respectively Product Complexity Indicator (PCI) and Economic Complexity Indicator (ECI) (see Section 2) instead of the measures of sophistication "PRODY" (product's sophistication, or income content associated with each product) and EXPY (country's sophistication, average income content of a country's export basket) to determine upscale opportunities. This is done to overcome the known criticism of the circularity around sophistication measures, i.e., that these are measured by comparison to the income level of countries with similar export structures, mechanically leading to the circular conclusion that "rich countries export rich-country products". By contrast, using Hidalgo and Hausmann's (2009[1]) economic complexity measures allows us to separate information on income from that on the network structure of countries and the products they export.

Finally, this paper also provides a more granular analysis using a high quality and more reliable trade database with respect to COMTRADE (see Section 2.1). Upscaling opportunities are calculated at the 6-digit product level, in order to mitigate the impact of integration into global value chains and of other countries' inputs being included in Costa Rica's gross export values, which would contaminate the results.

The result of applying the RRI method to the analysis of Costa Rica's production structure reveals that:

- Costa Rica’s export structure is a mix of high- and low-complexity exports, with a sizeable concentration around a few groups of products.
- Most of Costa Rica’s upscaling opportunities are in very-high-complexity products. Roughly 70% of the upscale opportunities lie in the sectors of machinery, electrical, plastics, rubbers, chemicals, and metals.

- A comparison of upscale opportunities among its Latin American peers reveals that Mexico is the only country in LAC6 (Argentina, Brazil, Chile, Colombia, Mexico and Peru) for which all upscaling opportunities rest in very-high-complexity products. Brazil, Argentina and Colombia, like Costa Rica, have upscaling opportunities among very-high- and high-complexity products while other economies, notably Costa Rica’s neighbours, as well as Peru and Chile, have lower opportunities to diversify into high complex products.

The remainder of the paper is structured as follows. Section 2 establishes the analytical framework by presenting the methodology, definitions and the data used. Section 3 presents the bipartite (countries-products) network structure of international trade using the Hidalgo and Hausmann (2009[1]) measures of product and country economic complexity (PCI and ECI, respectively) and Lebre de Freitas et al.’s (2015[2]) measures of revealed relatedness indexes (RRIs), outpath and density indexes. Section 4 provides a portrait of Costa Rica’s current export structure using the latter concepts, Section 5 identifies and characterises possible upscaling opportunities while Section 6 benchmarks them against those of other countries in Latin America. Section 7 concludes.

Data, definitions and methodology

Data

The analysis relies on cross-country export data from the BACI database, using the Harmonised System at the 6-digits level. The BACI database is developed by the CEPII, a French research centre in international economics. It is based on the data from the United Nations Statistical Division (COMTRADE database) using an original procedure that reconciles declarations of exporters and importers. This harmonisation procedure, which makes use of mirror trade flows, enables a considerably extension in the number of countries for which trade data are available, as compared to the original dataset (Gaulier and Zignago, 2010[11]).

The year used throughout this paper is 2015. In order to avoid results being driven by outliers, data were restricted to goods having a traded value greater or equal than USD 10 million, and to countries trading at least USD 1000 million and with a population greater than 1.25 million. Therefore, the data covers 4578 goods for 134 countries. Population figures were taken from the World Bank’s World Development Indicators.

Definitions

Economic Complexity Measures

Hidalgo and Hausmann (2009[1]) developed the method of reflections that consists of calculating jointly and iteratively the ubiquity and diversity indicators to introduce into the product and country complexity measures as much information as possible from the network structure of countries and traded products.[18]

Ubiquity and diversity are computed as follows:

$$\boldsymbol{UBIQUITY}_{\ i} = \boldsymbol{K}_{i,0} = \sum_i \boldsymbol{M}_{ic} \qquad \textbf{(3.1)}$$

$$\boldsymbol{DIVERSITY}_c = \boldsymbol{K}_{c,0} = \sum_c \boldsymbol{M}_{ic} \qquad \textbf{(3.2)}$$

where *c* denotes the country, *i* the product, and M_{ic} is equal to 1 if country *c* exports product *i* with Revealed Comparative Advantage and 0 otherwise. The index of Revealed Comparative Advantage (RCA) is defined following Balassa (1965[12]) as the ratio of the export share of a given product in the country's export basket to the same share at the worldwide level:

$$\boldsymbol{RCA}_{\ ic} = \frac{x_{ic}/x_c}{x_i/\sum_{d \in C} x_d} \qquad \textbf{(3.3)}$$

where X_{ic} symbolises country *c*'s exports of product *i*, X_c symbolises the total exports of country *c*, X_i symbolises the world exports of product *i*, and *C* symbolises the set of countries in the sample. A comparative advantage is revealed if RCA>1; if less than one, the country is said to have a comparative disadvantage in the product.

To generate an accurate measure of the number of capabilities available in a country, or knowledge embedded in a product, it is necessary to take the entire set of information on the bipartite network of the international trade structure comprising countries and products. For countries, this requires calculating the average ubiquity of the products it exports and the average diversity of the countries that make those products and so forth.[19] For products, this requires calculating the average diversity of the countries that make them and the average ubiquity of the other products that these countries make. In simpler terms, it is needed to correct the information that diversity and ubiquity carry by using each one to correct the other. This can be expressed by the recursion:

$$\boldsymbol{k}_c, \boldsymbol{N} = \frac{\boldsymbol{1}}{\boldsymbol{k}_{c,}\boldsymbol{0}} \sum_i \boldsymbol{M}_{ic} \ . \ \boldsymbol{k}_i, \boldsymbol{N} - \boldsymbol{1} \qquad \textbf{(3.4)}$$

$$\boldsymbol{k}_i, \boldsymbol{N} = \frac{\boldsymbol{1}}{\boldsymbol{k}_{i,}\boldsymbol{0}} \sum_c \boldsymbol{M}_{ic} \ . \ \boldsymbol{k}_c, \boldsymbol{N} - \boldsymbol{1} \qquad \textbf{(3.5)}$$

then insert (5) into (4) to obtain:

---

[18] Ubiquity is defined as the number of countries that make a product holding a comparative advantage. Complex products - those that embed more knowledge - are less ubiquitous. Diversity is the number of products in which a country holds a comparative advantage. Complex economies - those whose residents and organisations possess more knowledge - are more diverse.

[19] For a detailed methodological description see Hidalgo and Hausmann (2009[1]): Supplementary material for the building blocks of economic complexity.

$$\boldsymbol{k_c, N = \frac{1}{k_{c,0}} \sum_i M_{ic} \ . \ \frac{1}{k_{c,0}} \sum_{c'} M_{ic'} \ . \ k_{c'} \ , N-2} \quad \textbf{(3.6)}$$

$$\boldsymbol{k_c, N = \sum_{c'} M_{ic'} \ . \ k_{c'} \ , N-2 \ . \ \sum \frac{M_{ic}M_{ic'}}{k_{c,0}k_{i,0}}} \quad \textbf{(3.7)}$$

And rewrite as:

$$\boldsymbol{k_c, N = \sum_{c'} \widetilde{M}_{cc'} \ . \ k_{c'} \ , N-2 \ . \ \sum \frac{M_{ic}M_{ic'}}{k_{c,0}k_{i,0}}} \quad \textbf{(3.8)}$$

where

$$\boldsymbol{\widetilde{M}_{cc'} = \sum_i \frac{M_{ic}M_{ic'}}{k_{c,0}k_{i,0}}} \quad \textbf{(3.9)}$$

Note that (8) is satisfied when $k_c, N = k_c, N-2 = 1$. This is the eigenvector of $\widetilde{M}_{cc'}$ which is associated with the largest eigenvalue. Since this eigenvector is a vector of ones, it is not informative. It is required to look, instead, for the eigenvector associated with the second largest eigenvalue. This is the eigenvector that captures the largest amount of variance in the system and is our measure of economic complexity. Hence, we define the Economic Complexity Index (ECI) as:

$$\boldsymbol{ECI = \frac{\vec{K} - <\vec{K}>}{stdev(\vec{K})}} \quad \textbf{(3.10)}$$

where "< >" represents an average, "stdev" stands for the standard deviation and (3.11) $\vec{K}$ is the eigenvector of $\widetilde{M}_{cc'}$ associated with the second largest eigenvalue.

Analogously, Product Complexity Index (PCI) is defined as:

$$\boldsymbol{PCI = \frac{\vec{Q} - <\vec{Q}>}{stdev(\vec{Q})}} \quad \textbf{(3.12)}$$

where $\vec{Q}$ is the eigenvector of $\widetilde{M}_{pp'}$ associated with the second largest eigenvalue.

Upscale Opportunities

An upscale opportunity exists for each product the country does not have a comparative advantage in, but that is an up-scale product close to the country's current specialisation pattern (one whose PRODY is greater than the country's EXPY, i.e. the average income content of the country's export basket).

PRODY, a measure of income content for traded products, is computed as a weighted average of per capita income of the countries exporting these goods, with weights proportional to the RCAs:

$$\textbf{PRODY}_{\mathbf{i}} = \sum_{c \in C} \boldsymbol{Y_c * \sigma_{ic}}, \textbf{ having } \boldsymbol{\sigma_{ic} = \frac{RCA_{ic}}{\sum_{d \in C} RCA_{ic}}}, \quad \textbf{(3.13)}$$

where Y_c symbolises real GDP per capita in country c.

A product with high PRODY has a comparative advantage based on factors other than unskilled labour, such as technology, knowledge and public infrastructure; usually, goods with high PRODY are exported by rich countries. Using PRODY indexes, another measure is calculating, EXPY, which captures the average income content of a country's export basket:

$$\mathbf{EXPY}_{\mathbf{c}} = \sum_i \frac{x_{ic}}{X_c} * \boldsymbol{PRODY_i}, \qquad \textbf{(3.14)}$$

Through the production of a particular mix of goods, a country reveals its differences in endowments and capabilities developed such as technical knowledge, infrastructure, producer services, access to markets and specific regulatory requirements. These endowments and capabilities may be more favourable or more easily adapted to start producing some goods than others (Hausmann and Klinger, 2006[8]; Hausmann and Klinger, 2007[9]). Therefore, for assessing how valuable the productive experience with one product is to develop a comparative advantage in other goods, a measure of relatedness between pairs of products should be computed. This relatedness measures the likelihood of a country having comparative advantages in both products by estimating the minimum of the pairwise conditional probabilities of some country having a RCA in the one product, given that it has RCA in the other product. The relatedness is the main index for building the Product Space. A density measure is then calculated; it summarises the relatedness of that product with all the products in which the country has RCA. Haussman and Klinger (2006[8]; 2007[9]), as well as Hidalgo et al. (2007[5]), found that as countries change their export mix, there is a tendency to move towards related goods, rather than to goods that are less related to the current specialisation pattern.

Following Lebre de Freitas et al. (2015[2]), relatedness, outpath, and density are calculated as follows:

- Revealed relatedness index (RRI): Instead of computing conditional probabilities for the relatedness index, this adopts an alternative method named equality in probabilities. For each possible pair of products (i,j), these probabilities are estimated using the corresponding sample proportions – empirical probabilities - for the whole sample of countries:

  $$\mathbf{P}\,(M_{jc} = 1 \mid M_{ic} = 0) \textbf{ and } \mathbf{P}\,(M_{jc} = 1 \mid M_{ic} = 1), \qquad \textbf{(3.15)}$$

  where M_{kc} is a dummy variable equal to 1 if country *c* exports product *k* with RCA and 0 otherwise.

  The null hypothesis of equality of these two probabilities is tested for every *i* and *j*, using the standard two proportion z test. When the null hypothesis is rejected at α = *5%* significance level, it computes the increment in the probability of having a RCA in product *j* due to the fact of having a RCA in product *i:*

  $$\mathbf{RRI}_{ij} = \mathbf{P}\,(M_{jc} = 1 \mid M_{ic} = 1) - \mathbf{P}\,(M_{jc} = 1 \mid M_{ic} = 0), \qquad \textbf{(3.16)}$$

  $$\mathrm{RRI}_{ij} = \begin{matrix} 1 & : & : \\ : & 1 & : \\ : & : & 1 \end{matrix}$$

Any non-significant result sets the corresponding RRI to zero, meaning that the probability of having a RCA in product *j* does not depend on having a RCA in product *i*.

Due to the very large number of significance tests, it is possible to find a large number of increments in probability incorrectly found as significant. So, this controls the issue by setting a False Discovery Rate (FDR) at 5%.

- Outpath indexes: From the RRI matrix, the row perspective – outward - that is the sum of all RRIs per product i, measures the level in which the productive experience in a given product i is helpful to develop comparative advantages in other products *js*.

$$\textbf{Outpath}_{\mathbf{i}} = \sum_j \boldsymbol{RRI_{ij}} \qquad \textbf{(3.17)}$$

- Densities: This country-specific measure captures the extent to which a country's overall productive experience is helpful to start producing a given new product.

$$\textbf{Density}_{\mathbf{i,j}} = \sum_i \boldsymbol{RRI_{ij}} * \boldsymbol{M_{ic}} \qquad \textbf{(3.18)}$$

where M_{ic} symbolises the dummy variable defined in (3.16).

A high density concerning a particular product *j* that the country is not producing suggests that the country has endowments or accumulated experience that could easily be used or adapted for this product. Low densities suggest that the product under consideration is very unrelated to the country's core of capabilities. Lebre de Freitas et al. (2015[2]) demonstrated that their density measure provides a good predictor of future comparative advantages (average of densities = 2.75).

- Upscale products, value increments and upscale opportunities: Upscale products are those with higher income content – PRODY - than the country's average income content - EXPY. The "value increment" associated to product *i* in country *c* is defined by the expression:

$$\textbf{Ln (PRODY}_{\boldsymbol{i}} \textbf{ / EXPY}_{\boldsymbol{c}}\textbf{)} \qquad \textbf{(3.19)}$$

Product *i* will be labelled as an "upscale product" for country *c* when the corresponding "value increment" is positive.
Finally, an upscale opportunity will be a product with no current comparative advantage, but up-scaled and with a density larger than specific level (5, 10, 15…30).

Adjusted methodology

We now depart from Lebre de Freitas et al. (2015[2]) and incorporate two adjustments regarding the indexes used to determine upscale products and the statistical scrutiny when computing RRIs:

- Determining upscale products: We substitute sophistication measures that are based on income content (PRODY and EXPY), for economic complexity measures (PCI and ECI). This is done in order to answer the criticism of the circularity involving the sophistication measures (Felipe et al., 2012[13]). The problem with sophistication measures is that these are measured by comparison to the income level of countries with similar export structures, mechanically leading to the circular conclusion that “rich countries export rich-country products”. By contrast, Hidalgo and Hausmann’s (2009[1]) economic complexity measures separate information on income from that on the network structure of countries and the products they export.

- Statistical scrutiny for Revealed Relatedness Indexes (RRIs): Estimating RRIs implies a very large number of significance tests. Then, it is possible to find a large number of increments in probability incorrectly found as significant. In order to avoid potential false positives, the significance level α for rejecting the null hypothesis of equality of probabilities is narrowed, moving α from 5% to 0.5%.

Table 3.1 provides a summary of the methodology used in this paper to determine upscale opportunities combining Hidalgo-Hausmann’s framework and Lebre de Freitas et al. (2015[2]) and our own adjustments to each method:

Table 3.1. Computing stages in the RRI methodology

#	Computing stage	Description
1	RCA $_{ic}$	Revealed Comparative Advantage (RCA $_{ic}$) in product *i* for each country *c,* following Balassa (1965[12]).
2	PCI $_{i}$	PCI $_{i}$, Product Complexity Index of product *i*, following Hidalgo and Hausmann (2009[1]).
3	ECI $_{c}$	ECI $_{c}$, Economic Complexity Index of country c, following Hidalgo and Hausmann (2009[1]).
4	Upscale products	Exported products, by a given country, with higher PCIs than the country’s ECI.
5	Opportunity Value or Value Increment	The “opportunity value” associated to product*i* in country *c*is defined by the expression: PCI $_{i}$ - ECI $_{c}$. Product *i* will be labelled as an “upscale product” for country *c* when the corresponding “opportunity value” is positive.
6	RRI $_{ij}$	Revealed relatedness index (RRI) per each pair of products (*i,j*) for all countries, following Lebre de Freitas et al. (2015[2]). Adjustment: Significant level at 0.5% for testing the null hypothesis of equality of probabilities.
7	Outpath $_{i}$	It refers to the productive experience in a given product *i* that is helpful to develop a comparative advantage in others, following Lebre de Freitas et al. (2015[2]).
8	Density $_{jc}$	Overall productive experience of the country *c* that is helpful to start producing a given product j, following Lebre de Freitas et al. (2015[2])
9	Upscale opportunities	Products with RCA<1 that are upscale (PCI $_{i}$ > ECI $_{c}$) and lie in a range of densities larger than a specific level (5), following Lebre de Freitas et al. (2015[2]).

Characterising the structure of international trade

Revealed Relatedness Indexes (RRIs)

The RRI, obtained in Equation 3.16, captures how valuable the productive experience with one good is in developing a comparative advantage in another one, helping in the process of structural transformation. The RRI $_{ij}$ estimates the increment in the probability of having RCA in product j due to the fact of having RCA in product i. For the sample used in this paper of 134 countries and 4578 goods, a non-symmetric matrix of RRIs composed by 4578*4577 = 20 953 506 values is computed. Table 3.2 contains some statistics of these estimations.

Table 3.2. Summary results of the RRI estimation

	Number	% of total	% of significance
Observations	20,953,506	100.0	
Non-significant	20,189,340	96.35	
Significant	764,166	3.65	100.0
Positive	*751,126*	*3.58*	*98.29*
Negative	*13,040*	*0.06*	*1.71*

The significance tests for the estimated RRIs determine as a RRI to be non-significant when few countries have comparative advantage in one of the goods (*i,j*). Among the almost 21 million estimated RRIs, only 3.65% are significant. This restricts the available options of countries in the process of structural transformation. In the case of a negative and significant RRI, the measure captures the possibility of some capabilities or knowledge used in the production of one good being unfavourable to the production of another (Lebre de Freitas et al., 2015[2]). The number of negative RRIs which are significant is small, 13 thousands out of 21 million, or 0.06%. For most of the goods (98%) where at least one RRI is negative, the sum of all significant RRIs is positive, therefore, in general, specialisation in these products seems to offer a valuable productive experience to start producing other goods.

The RRI method does not impose symmetry in the matrix of product relatedness as Hidalgo and Hausmann (2009[1]) and Hausmann and Hidalgo (2011[6]) did. Consider two related products: "*854800 - electrical Parts of Machinery and Apparatus*" and "*853329 - electrical Resistors*". A country with a comparative advantage in Electrical Parts of Machinery and Apparatus could possibly also develop expertise in producing Electrical Resistors. However, producing Electrical Resistors does not necessarily endow a country with the required knowledge to produce Electrical Parts of Machinery and Apparatus. Checking the estimated RRIs, we detect that the productive experience achieved in the production of "*854800 - electrical parts of machinery and apparatus*", increases the probability of being specialized in "*853329 - electrical resistors*" by 62 percentage points. Specialisation in electrical resistors increases the probability of being specialised in electrical parts by 44 percentage points. The same applies to other related products such as "*80430 - pineapples, fresh or dried*" and "*200940 - pineapple juice, not fermented or spirited*" (36 vs 27 percentage points). As shown, the asymmetric matrix of RRIs would suggest more accurate estimations than those obtained in Hidalgo and Hausmann (2009[1]) and Hausmann and Hidalgo (2011[6]). In addition, asymmetry allows us to observe two perspectives from each product point of view: a row ("outward") perspective that measures the level in which the productive experience in a given product is helpful to develop comparative advantages in other products; and a column ("inward") perspective: a country-specific measure that captures the extent to which a country's overall specialisation pattern is helpful to start producing a given new product (Lebre de Freitas et al., 2015[2]).

In Table 3.3, estimated RRIs are shown for one specific row of the matrix of RRIs. The chosen row refers to product "*901890 – medical, surgical or dental instruments and appliances*" in which Costa Rica has considerable productive experience. The matrix is read in the following way: the productive experience in "medical, surgical, or dental instruments and appliances", increases the probability of having a comparative advantage in "*901831 – "syringes, with or without needles*" by 60 percentage points.

Table 3.3. Row RRIs for 901890 – Medical, surgical or dental instruments and appliances

Product j (code)	RRI	Product j (description)
901831	0.60	Syringes, with or without needles
540333	0.53	Yarn of cellulose acetate, single, not retail
902119	0.51	Orthopaedic/fracture appliances
902750	0.49	Instruments using optical radiations
370210	0.48	Photographic film, rolls, for x-ray
392190	0.48	Plastic sheet, film, foil or strip
291090	0.48	Epoxides, epoxy-alcohols,-phenols,-ethers nes, derivs
291100	0.48	Acetals and hemiacetals, derivatives
901819	0.47	Electro-diagnostic apparatus
901811	0.46	Electro-cardiographs
321410	0.45	Mastics, painters' fillings
350400	0.45	Peptones, proteins and derivatives, hide powder
281610	0.43	Magnesium hydroxide and peroxide
392091	0.43	Sheet/film not cellular/reinf polyvinyl butyral
350610	0.42	Glues and adhesives of all kinds, package <1 kg
903300	0.42	Parts/accessories nes for optical/electric instrument
392510	0.42	Plastic reservoirs, tanks, vats, etc, capacity <300l
392690	0.42	Plastic articles
320820	0.41	Acrylic or vinyl polymer paint or varnish, non-aqueou
300640	0.41	Dental cements and other dental fillings, bone cement

Outpath and density indexes

The row ("outward") perspective of the RRIs matrix captures the outpath index obtained following Equation 3.17. A high outpath for a particular product *i* indicates that its productive experience is very useful to start producing other products, in general. The 225 goods with the highest estimated outpath indexes (top 5%) belong to the categories: "machinery and electrical" (40%), "plastics, rubbers and chemicals" (16%), "metals" (15%), "instruments and appliances" (9%), "textiles" (9%) and "transportation" (5%). In contrast, products in the sectors of "agriculture", "foodstuffs", "oil and minerals", "footwear and headgear" have low output indexes. Annex A shows the 50 items with highest estimated outpath indexes.

The column ("inward") perspective regards a country-specific measure that captures the extent to which a country's overall specialisation pattern is helpful to start producing a given new product. This is obtained using Equation 3.19. A high density for a particular product *j* that the country is not producing suggests that the country has endowments or accumulated experience that can easily be used or adapted for this product. Low densities suggest that the product under consideration is very unrelated to the country's core of capabilities. Lebre de Freitas et al. (2015[2]) showed that their density measure provides a good predictor of future comparative advantages (average of densities = 2.75). For the purpose of this paper, we set the density level each 5 units from 5 to 45.

Results for Costa Rica

Costa Rica's export structure reveals is a mix of high- and low-complexity exports

This section characterises Costa Rica's export structure, focusing on the top 15 exported products which accounted for approximately 60% of Costa Rican exports in 2015. Overall results are detailed in Annex B. Costa Rica enjoys a strong specialisation in a number of agriculture products, showing revealed comparative advantages (RCAs) well above one, for example in products "*80430 - pineapples, fresh or dried",* with a RCA of 726.3, "*200940 - pineapple juice, not fermented or spirited*", with a RCA equals to 255.7, and "*80300- bananas, including plantains, fresh or dried*" with a RCA of 130. However, there are two more technological-intensive product categories which also have very high RCAs: "medical instruments and appliances" and "electrical goods".

Half of the top 15 products belong to the third or fourth quartiles of product complexity showing an appreciable level of knowledge embedded in the country. For instance, product "*902130-artificial body parts, aids and appliances*" has the highest PCI among the top 15 (PCI = 1.4), locating it in the fourth quartile (most complex products). In contrast, product "*90111-Coffee, not roasted, not decaffeinated*" lies in the first quartile (least complex products) having a PCI equal to -2.7.

Table B.1 in Annex B displays also the number of significant Revealed Relatedness Indexes (RRIs) for each product, labelled as "*ni"*. These RRIs refer to the increment in the probability of having RCA in a product *j*, given that a country has RCA in one of these 15 products. For example, specialisation in product "*902130-artificial body parts, aids and appliances"* influences the probability of having a RCA in 217 products. By contrast, product "*80300-bananas, including plantains"* only influences the RCA probability of 41 products. Among the top 15 products, the one which influences the likelihood of Costa Rica having comparative advantage in the most products is product "*401110-pneumatic tyres new of rubber for motor cars*" with 270 significant RRIs. Notice that very few RRIs are negative, which means that in very few cases these top products have adverse effects on others for developing comparative advantage.

Using outpath indexes helps capture the overall usefulness of the productive experience achieved in one product for a country to start producing others. In the case of Costa Rica, the products that appear to be more useful in terms of the capabilities they use are products "*902130-artificial body parts, aids and appliances"*, and "*847330-parts and accessories of data processing equipment"*. On the other hand, producing "*80300-bananas, including plantains, fresh or dried"* is less interesting in terms of its learning potential. Merging the information provided by the outpath indexes with those of product complexity by splitting the outpath index for each product into the PCI quartiles of the others, reveals that most of the output of product "*401110-pneumatic tyres new of rubber for motor cars"* is favourable to products within the third and fourth PCI quartile (high and very high complexity), while most of the output of product "*80430 - pineapples, fresh or dried"* is favourable to products within the first and second PCI quartile (very low and low complexity).

Costa Rica specialises in a number of related products

The density indexes, which assess the relation between a product and the country's specialisation pattern (Equation 3.19), reveal that the products in which Costa Rica is specialised (RCA>1) are very related to each other. About 73.6% of the products, 306 out of 416, have densities greater or equal to 5 (Table 3.4), a level considered acceptable to identify a specialisation pattern. Notice that the closer a product is to Costa Rica's current specialisation pattern (i.e., the higher its density index), the higher its Opportunity Value.

Table 3.4. Summary statistics for products in which Costa Rica has RCA>1

Densities	Number of products	% of total products	Share of Total Exports (%)	Opportunity Value (simple average)	Opportunity Value (weighted average)
<5	110	26.4	4.4	-0.8	-0.1
[5,10[	126	30.3	27.8	-0.8	-0.3
[10,15[	69	16.6	37.9	-0.7	-0.3
[15,20[	46	11.1	10.3	-0.4	-0.2
[20,25[	24	5.8	2.7	0.0	0.0
[25,30[	11	2.6	1.7	-0.3	-0.1
[30,35[	16	3.8	5.4	-0.2	-0.1
[35,40[	7	1.7	0.9	-0.2	0.0
>=40	7	1.7	1.0	-0.2	0.0
Total	416	100.0	92.3		

Note: Weights of the opportunity value (weighted average) are export shares.

Table C.1 in Annex C lists the 50 most exported products of Costa Rica, regardless of RCAs, ranked by the density index. These products account for 75% of the Costa Rican export basket. Almost all products have densities above 5, except for products *"71410-manioc (cassava), fresh or dried"* and *"20230-bovine cuts boneless, frozen*". Higher densities are found in products belonging to categories such as foodstuffs; plastic, rubbers and chemicals; machinery; electrical products; agriculture, and instruments. Products in the categories of foodstuffs; agriculture; animal and animal products, have negative opportunity value mainly because of the associated low or very low level of complexity. The largest 15 exported products (60% of exports) fit well in the country's specialisation pattern with densities between 7.6 for product category *"901839-needles, catheters, cannulae (...)"* (medical products) and 31.6 for products classified as *"210690-food preparations"*; this set has a density average of 13.9 and standard deviation equals 5.8.

Upscaling opportunities for Costa Rica

About 74% of the products in which Costa Rica has RCA>1 have densities above 5 (Table 3.4). At this level of density for products with RCA<1, we identify 570 upscale opportunities for Costa Rica (Table 3.5). For a much more stringent density level of 15, which covers the top 26.7% of products in which Costa Rica has a comparative advantage, there are 101 upscale opportunities. For densities above 25 (corresponding to the top 9.8% in terms of products with RCA>1), there are 9 upscale opportunities. Notice that the upscale products that more related to the specialisation pattern (i.e., that have higher densities) tend to exhibit lower opportunity values on average, than the upscale products with lower densities.

Table 3.5. Summary statistics for upscale products in which Costa Rica has RCA<1

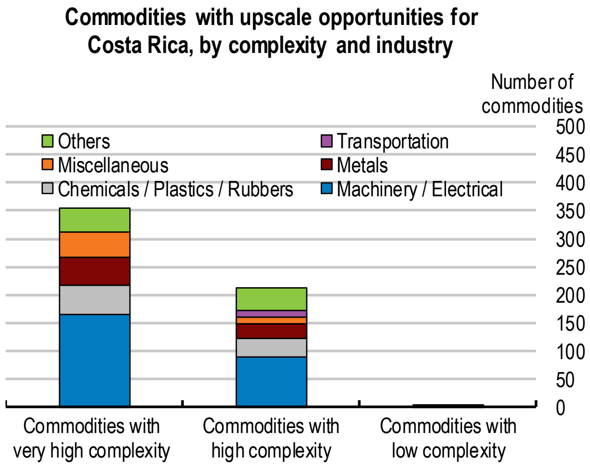
Densities	Number of products	% of total products	Share of Total Exports (%)	Opportunity Value (simple average)
<5	671	54.1	0.54	0.58
[5,10[	314	25.3	1.11	0.64
[10,15[	155	12.5	0.55	0.73
[15,20[	64	5.2	0.51	0.56
[20,25[	28	2.3	1.45	0.54
[25,30[	7	0.6	0.17	0.39
[30,35[	1	0.1	0.01	0.19
[35,40[	1	0.1	0.02	0.11
>=40	0	0	0	
Total	1241	100.0	4.36	

What are the products and to which sectors do they belong?

Annex D lists the 570 upscale opportunities detected for Costa Rica in 2015. About 62% and 37% of the opportunities are products with a “very high” or “high” level of complexity respectively, reflecting that Costa Rica possesses already in its production structure a level of knowledge (ECI=0.27) that allows it to exploit these opportunities and to specialise in very high complexity products (Figure 3.3, Table 3.6). The composition by sector is shown in Figure 4. Roughly 70% of the upscale opportunities lie in the sectors of machinery, electrical products, plastics, rubbers, chemicals, and metals.

Annex E lists the upscale opportunities grouped by family of products for each economic sector. Families of products with the most of upscale opportunities are: *“8707-parts and accessories for motor vehicles”* (12 products), *“8703-motor cars and motor vehicles”* (8), *“8421- centrifuges, including centrifugal dryers”* (9), “*7318- screws, bolts, nuts, coach screws, screw hooks, rivets, cotters, cotter-pins, washers (including spring washers) and similar articles, of iron or steel”* (8), *“8419-machinery, plant or laboratory equipment for the treatment of materials by a process involving change of temperature” (i.e. heating, cooking, etc.); “instantaneous or storage water heaters, non-electric”* (7), *“8433-harvesting and threshing machinery”* (6), *“9027-instruments and apparatus for physical or chemical analysis”* (6). One of the top exporting products categories – foodstuffs - has downscale products because of lower level of complexity among primary goods and the food industry.

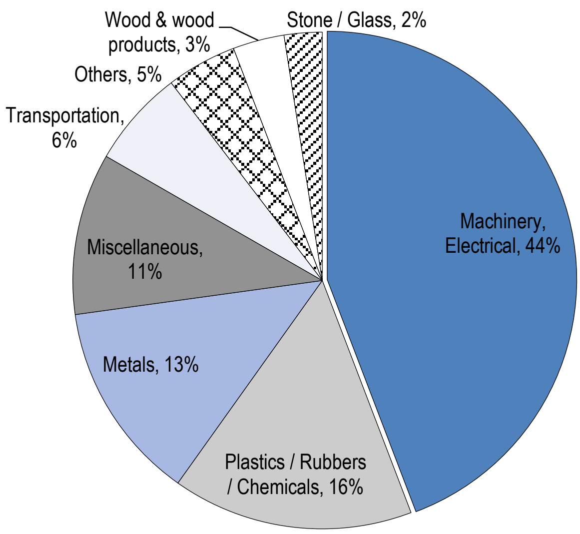
Figure 3.3. Most of Costa Rica's upscaling opportunities are in very high complexity products



Note: Upscale opportunities are those commodities currently exported with no comparative advantage, with a level of complexity (PCI) higher than the country's complexity index and which are closer to the country's specialisation pattern. Products are classified according the Product Complexity Index (PCI), very high and high refers to the 4th and 3rd quartile of PCI.

Figure 3.4. Sectoral composition of the upscale opportunities for Costa Rica

570 upscale opportunities corresponding to densities higher than 5



Note: Most of the “miscellaneous opportunities” (80%) are products relating to “instruments and appliances”

Table 3.6. Upscale opportunities by sector and PCI Quartile

Sector	Total	I	II	III	IV
Machinery / Electrical	252			88	164
Plastics / Rubbers / Chemicals	89		1	35	53
Metals	74			25	49
Miscellaneous	60		1	13	46
Transportation	36		2	12	22
Wood & wood products	19			13	6
Stone / Glass	14			8	6
Animal & Animal Products	12			8	4
Textiles	6			3	3
Foodstuffs	6			5	1
Footwear / Headgear	1			1	
Vegetable Products	1			1	
Total	570	0	4	212	354

Note: "I Quartile" refers to the least complex product while IV Quartile to the most complex products.

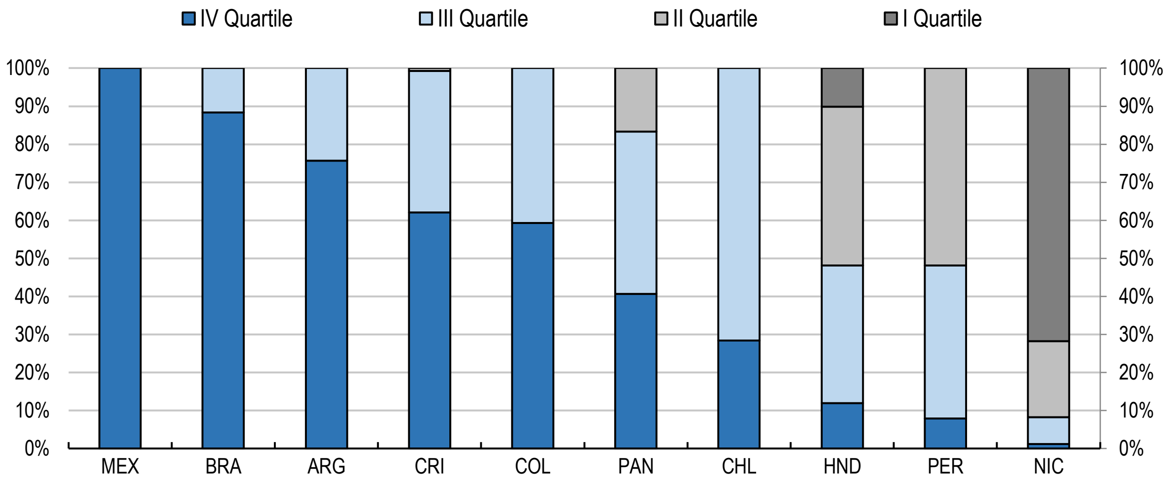
Benchmarking Costa Rica's upscaling opportunities with other Latin American economies

This section benchmarks Costa Rica's upscaling opportunities with those of other Latin American countries: LAC6 (Argentina, Brazil, Chile, Colombia, Mexico and Peru) and neighbouring Central American countries (Honduras, Nicaragua and Panama). The current export share of these upscaling opportunities is low for all countries (Table 3.7). All opportunities for Mexico are among the most complex products (IV Quartile). Brazil, Argentina, Costa Rica and Colombia have most of their opportunities ranked within the third and fourth quartiles of product complexity. Panama, Honduras, Peru and Nicaragua reflect more diverse compositions, having more opportunities within the lower quartiles, showing a sequential path for upgrading their exports due to the current low levels of complexity embedded in their production (Figure 3.5).

Table 3.7. Number of upscaling opportunities and current export share

Country	# of Upscale Opportunities (densities above 5)	Share of country's exports (%)
BRA	557	5.65
ARG	419	5.29
PAN	625	5.27
CRI	570	3.82
COL	403	2.84
MEX	293	2.15
HND	218	1.18
PER	164	0.48
CHL	95	0.33
NIC	85	0.32

Figure 3.5. Upscale opportunities by complexity level



Note: Upscale opportunities set at densities above 5. Quartile measures associated to the Product Complexity Index where the fourth quartile stands for the most complex product and the first for the least.

A visual representation of upscale opportunities for the sample of countries is presented in Figure 3.6. This reflects that specialisation patterns are not all the same in terms of preparing a country to develop comparative advantages in new products. While countries such as Mexico and Costa Rica seem to be well prepared to start producing new and complex products, countries such as Chile, Nicaragua or Peru have limited capabilities to move to high levels of complexity until they develop further capacities. Mexico has 67 upscale opportunities at densities above 25 whereas Chile does not have any upscale opportunity even at a lower threshold, above 15.

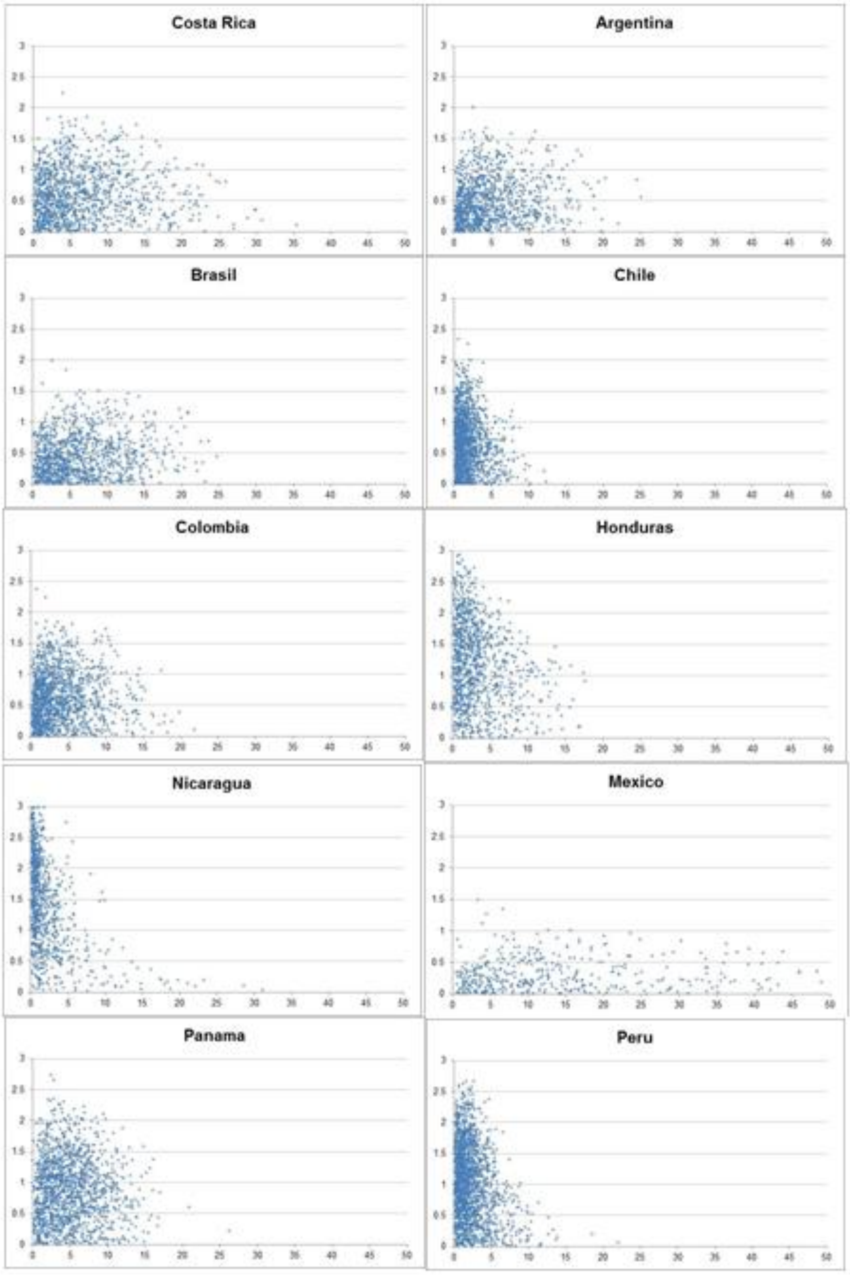
The visual representation shows that countries with lower levels of complexity such as Honduras, Nicaragua or Peru (with country indexes of overall complexity, ECI, of -0.83, -1.4, and -0.49 respectively), have more products with higher opportunity values than countries with higher overall complexity, such as Costa Rica (ECI equal to 1.4) and Mexico (ECI equal to 1.16). However, not all possibilities are easily realised, as countries with lower levels of complexity typically have a distribution of higher opportunity values in products that are very distant from their current capability set (i.e. with a density lower than 5) (Figure 3.6).

Table 3.8 shows the upscale opportunities for the sample of countries by economic sector at density levels above 5, 15 and 25. At a density level above 5, the most optimistic scenario where a country can develop comparative advantages in products that are not close to the country's core capabilities, all the countries in the sample appear to have upscale opportunities. In the case of Costa Rica, most of the products with a RCA greater than one (roughly 75%) lie above this threshold which means that this level is still relevant for detecting upscale opportunities. The sector composition of the Costa Rican opportunities (570 products) is similar from those at densities above 15 and 25, being more important in machinery, electrical products (252); plastics; rubbers; chemicals (99); metals (74); miscellaneous (60) and transportation (36). At this level, Panama exhibits the highest number of opportunities (625) half of those within the machinery and transportation sectors. Moreover, Central American peers Honduras (285) and Nicaragua

(85) have the lowest potential. Textiles is the most relevant sector for Nicaragua, which is evidence of the country's low complexity level (ECI = -1.4).

Figure 3.6. Visual representation of upscale opportunities for a sample of countries

X axis: Density; Y axis Opportunity Value



Note: These figures show products with RCA<1, and positive densities and opportunity values

Table 3.8. Upscale opportunities by country at specific density levels

Country [2015 ECI ranking]	CRI [55th]			ARG [45th]			BRA [36th]			CHL [62nd]			COL [54th]			MEX[23rd]		
Category / Densities higher than	5	15	25	5	15	25	5	15	25	5	15	25	5	15	25	5	15	25
Machinery_Electrical	252	43	3	160	13	1	210	27		26			156	2		92	56	35
Metals	74	9	2	56	6		77	10		8			54	2		55	28	12
Chemicals_and_Allied_Industries	44	11	1	56	4		96	3		7			48	5		61	15	5
Miscellaneous	60	2		39			48	1		6			36			38	24	9
Plastics_Rubbers	45	12	1	44	5		59	11		15			41	1		27	10	4
Textiles	6	1		5			11			2			6			3	1	
Transportation	36	9		27	4		23	6		7			25			4	2	1
Wood_and_wood_products	19	5	2	8	1		12	1		12			16	3		4	1	
Stone_Glass	14	5		13			13			3			13			6	3	1
Foodstuffs	6	3		3			2			5			5					
Animal_and_Animal_Products	12	1		5			4	1		4			1			3	1	
Vegetable_Products	1			3			2						1					
Footwear_Headgear	1												1					
Raw_Hides_Skins_Leather_Furs																		
Mineral_products																		
Total of products	570	101	9	419	33	1	557	60	0	95	0	0	403	13	0	293	141	67
Summary (% of total products)																		
Agriculture, mineral, wood	7%	9%	22%	5%	3%	0%	4%	3%		22%			6%	23%		2%	1%	0%
Textiles, Hides, leather, footwear	1%	1%	0%	1%	0%	0%	2%	0%		2%			2%	0%		1%	1%	0%
Machinery,Transport,Miscellanous	64%	58%	33%	57%	52%	100%	53%	57%		44%			57%	15%		48%	60%	69%
Plastics, rubbers, chemicals	16%	23%	22%	24%	27%	0%	28%	23%		23%			22%	46%		30%	18%	13%
Metals	13%	9%	22%	13%	18%	0%	14%	17%		8%			13%	15%		19%	20%	18%

Table 3.9. Upscale opportunities by country at specific density levels

Country [2015 ECI ranking]	CRI [55th]			HND [105th]			NIC [123rd]			PAN [74th]			PER [87th]		
Category / Densities higher than	5	15	25	5	15	25	5	15	25	5	15	25	5	15	25
Machinery_Electrical	252	43	3	34			2			229			24		
Metals	74	9	2	32			1			91	4		23		
Chemicals_and_Allied_Industries	44	11	1	15	2		5			65	3		14		
Miscellaneous	60	2		25			4			82			16		
Plastics_Rubbers	45	12	1	19	1		2			45			15		
Textiles	6	1		31	3		28	8	2	29	2	1	37	2	
Transportation	36	9		7			1			29	2		4		
Wood_and_wood_products	19	5	2	21			6			26	1		12		
Stone_Glass	14	5		11			7			15			6		
Foodstuffs	6	3		11	1		5			8			9		
Animal_and_Animal_Products	12	1		1			4			3			2		
Vegetable_Products	1			5			2			1			2		
Footwear_Headgear	1			2			10	2		2					
Raw_Hides_Skins_Leather_Furs				4			8	2							
Mineral_products															
Total	570	101	9	218	7	0	85	12	2	625	12	1	164	2	0
Summary (% of total products)															
Agriculture, mineral, wood	7%	9%	22%	17%	14%		20%	0%	0%	6%	8%	0%	15%	0%	
Textiles, Hides, leather, footwear	1%	1%	0%	17%	43%		54%	100%	100%	5%	17%	100%	23%	100%	
Machinery,Transport,Miscellanous	64%	58%	33%	35%	0%		16%	0%	0%	57%	17%	0%	30%	0%	
Plastics, rubbers, chemicals	16%	23%	22%	16%	43%		8%	0%	0%	18%	25%	0%	18%	0%	
Metals	13%	9%	22%	15%	0%		1%	0%	0%	15%	33%	0%	14%	0%	

Conclusion

This paper investigates how an economy's structural transformation process could be driven by its existent production structure and capabilities. Using the structure of international trade in 2015, we combine measures of economic complexity (Hidalgo and Hausmann, 2009[1]) with a method for identifying upscale opportunities in the process of structural transformation developed by Lebre de Freitas et al. (2015[2]). This allows us to determine a set of products that is more complex than the country's current level and for hich the country has the potential to develop a comparative advantage in the future. The analysis is performed for Costa Rica, a small open economy, using neighbouring countries and the largest economics (LAC6) in Latin America as a benchmark.

This paper contributes to the literature on economic complexity by adjusting the method developed by Lebre de Freitas et al. (2015[2]) in two important ways: first, we substitute sophistication measures that are based on income content (PRODY and EXPY), for economic complexity measures (PCI and ECI), thus avoiding the circularity criticism attached to the income level of countries (Felipe et al., 2012[13]). The second adjustment we perform allows narrowing greatly the significance level α for rejecting the null hypothesis of equality of probabilities to estimate the RRIs more accurately. We conduct 21 million significance tests, having narrowed the significance level used in previous studies from 5% to 0.5%, which helps avoiding potential false positives. Analysis is performed at a highly disaggregated 6 digit product level, minimising issues associated with double counting of gross trade flows associated with countries' participation in global value chains. Moreover, the use of the BACI database provides more reliable estimates than using COMTRADE, as BACI offers higher quality data on international trade flows.

Our results show that most of the 416 products for which Costa Rica exhibits a revealed comparative advantage (RCA) are inside the country's capability core, i.e, they are all produced using the country's endowments, including knowledge and productive experience (density). Furthermore, Costa Rica's top 15 exported products, all with a positive comparative advantage, show an average density of 13.9, exceeding by several times the threshold of 5, which defines countries' inner production capabilities..

In general, the specialisation pattern of Costa Rica includes sectors such as machinery; electrical products and parts (integrated circuits, parts of data processing equipment, mounted piezo-electric crystals); instruments (medical instruments and appliances, artificial body parts, needles catheters); and agriculture and foodstuffs (bananas, pineapples, coffee, food preparations, pineapple juice).

Our results also reveal that Costa Rica's upscale opportunities are found in machinery and electric products (44% of opportunities); plastics, rubbers and chemicals (16%); metals (13%); miscellaneous instruments (11%); and transportation (6%). In addition, 62% and 37% of the upscaling opportunities are in products with very high or high levels of complexity, respectively. Families of products with the most of upscale opportunities are: "*8707-parts and accessories for motor vehicles*" (12 products), "*8703-motor cars and motor vehicles*" (8), "*8421- centrifuges, including centrifugal dryers*" (9), "7318- *screws, bolts, nuts, coach screws, screw hooks, rivets, cotters, cotter-pins, washers (including spring washers) and similar articles, of iron or steel*" (8), "*8419-machinery, plant or laboratory equipment for the treatment of materials by a process involving change of temperature" (i.e. heating, cooking, etc.); "instantaneous or storage water heaters, non-electric*" (7), "*8433-harvesting and threshing machinery*" (6), "*9027-instruments and apparatus for physical or chemical analysis*" (6). One of the top exporting products categories – foodstuffs - has downscale products because of lower level of complexity among primary goods and the food industry.

When comparing Costa Rica with neighbouring and larger Latin American economics, we observe that Costa Rica and Mexico seem to be well prepared to start producing new and complex products compared to their peers, showing more upscale opportunities at superior density levels. Countries such as Chile, Nicaragua or Peru may have limited knowledge for diversifying into products of very high or high complexity. Overall, sectors in which Costa Rica exhibits substantial upscale opportunities are machinery; electrical; metals; plastics; rubber; and chemicals.

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Annex A.

Table A.1. Top 50 estimated outpath indexes

ID	Product	Category	Outpath
731816	Nuts, iron or steel	Metals	362.7
731829	Non-threaded articles of iron or steel	Metals	315.3
391990	Self-adhesive plates, sheets, film, plastic, w >20 cm	Plastics / Rubbers	301.3
382100	Prepared culture media for developing micro-organisms	Chemicals & Allied Industries	301.2
848360	Clutches, shaft couplings, universal joints	Machinery / Electrical	293.3
848340	Gearing, ball screws, speed changers, torque converte	Machinery / Electrical	285.1
391190	Polysulphides, polysulphones etc, nes in primary form	Plastics / Rubbers	284.5
846150	Metal sawing or cutting-off machines	Machinery / Electrical	277.4
731819	Iron or steel threaded articles except screw, nut,bol	Metals	274.8
848390	Parts of power transmission etc equipment	Machinery / Electrical	267.9
750712	Tubes and pipe, nickel alloy	Metals	265.8
731822	Washers, iron or steel, except spring/lock	Metals	264.1
848180	Taps, cocks, valves and similar appliances	Machinery / Electrical	263.6
732690	Articles of iron or steel	Metals	260.8
841350	Reciprocating positive displacement pumps	Machinery / Electrical	257.7
750620	Plates, sheet, strip and foil, nickel alloy	Metals	254.7
842199	Parts for filter/purifying machines for liquid/gas	Machinery / Electrical	254.6
391000	Silicones in primary forms	Plastics / Rubbers	253.1
830242	Mountings, fittings, of base metal, for furniture, ne	Metals	252.5
960622	Buttons of base metal, not covered with textile	Miscellaneous	251.3
841231	Pneumatic power engines/motors, linear acting	Machinery / Electrical	248.4
841480	Air or gas compressors, hoods	Machinery / Electrical	248.2
842430	Steam or sand blasting machines	Machinery / Electrical	247.8
820830	Blades for kitchen appliances & food industry machine	Metals	246.4
870839	Brake system parts except linings for motor vehicles	Transportation	244.8
340399	Lubricating preparations, zero petroleum content	Chemicals & Allied Industries	244.4
842720	Self-propelled works trucks, non-electric	Machinery / Electrical	244.0
848190	Parts of taps, cocks, valves or similar appliances	Machinery / Electrical	243.9
847790	Parts of machines for working rubber or plastic	Machinery / Electrical	243.4
848120	Valves for oleohydraulic or pneumatic transmissions	Machinery / Electrical	242.3
846090	Machine tools for finishing metals	Machinery / Electrical	240.6
846789	Tools for working in hand, non-electric motor	Machinery / Electrical	239.7
400950	Rubber tube, pipe or hose with fittings	Plastics / Rubbers	238.9
843139	Parts of lifting/handling machinery	Machinery / Electrical	237.7

842420	Spray guns and similar appliances	Machinery / Electrical	236.8
843280	Rollers, soil preparation, cultivation machinery	Machinery / Electrical	236.6
846630	Dividing heads/attachments for machine tools	Machinery / Electrical	234.9
841490	Parts of vacuum pumps, compressors,fans,blowers,hoods	Machinery / Electrical	234.7
848071	Moulds, injection & compression, for rubber or plasti	Machinery / Electrical	234.6
902290	Parts and accessories for radiation apparatus	Miscellaneous	233.3
902211	Medical X-ray apparatus	Miscellaneous	232.2
846291	Hydraulic presses for working metal	Machinery / Electrical	232.1
732393	Table/kitchen articles, parts, stainless steel	Metals	231.9
731821	Washers, spring or lock, iron or steel	Metals	229.7
871140	Motorcycles, spark ignition engine of 500-800 cc	Transportation	229.7
731590	Chain parts, iron or steel, except articulated link	Metals	228.2
901730	Micrometers, callipers and gauges	Miscellaneous	227.8
870892	Mufflers and exhaust pipes for motor vehicles	Transportation	227.5
846792	Pneumatic hand tool parts	Machinery / Electrical	225.8

Annex B.

Table B.1. Summary statistics for top 15 exported products in which Costa Rica is currently specialised

											Outpath by PCI Quartile			
ID	Product	Category	Export Share %	RCA	PCI	PCI Quartile	ni	ni>0	ni<0	Outpath	I	II	III	IV
80300	Bananas, including plantains, fresh or dried	Agriculture	9.8	130.0	-2.3	I	41	39	2	16.0	14.9	1.7	-0.3	-0.3
80430	Pineapples, fresh or dried	Agriculture	9.6	726.3	-2.0	I	52	52	0	24.5	20.7	2.2	1.6	0.0
901890	Instruments, appliances for medical, for science.	Instruments	8.7	29.8	0.7	III	182	180	2	59.7	0.3	3.8	13.9	41.6
854219	Monolithic integrated circuits, except digital	Machinery / Electrical	6.6	2.3	0.7	III	180	178	2	81.8	2.0	8.2	29.3	42.2
901839	Needles, catheters, cannulae etc., (medical)	Instruments	6.4	43.2	0.3	III	79	79	0	31.3	0.8	6.6	8.7	15.1
902130	Artificial body parts, aids and appliances, etc.	Instruments	3.3	50.9	1.4	IV	217	217	0	90.5	0.4	10.5	21.9	57.7
210690	Food preparations	Foodstuffs	2.9	13.6	-0.2	II	244	229	15	61.9	0.4	22.2	19.8	19.6
90111	Coffee, not roasted, not decaffeinated	Agriculture	2.7	21.3	-2.7	I	152	129	23	48.0	52.3	1.2	-3.8	-1.8
847330	Parts and accessories of data processing equipment	Machinery / Electrical	1.3	2.0	0.5	III	232	230	2	92.2	8.0	18.4	35.9	30.0
200940	Pineapple juice, not fermented or spirited	Foodstuffs	1.3	255.7	-1.4	I	54	53	1	21.0	18.8	1.9	0.3	0.0
854800	Electrical parts of machinery and apparatus	Machinery / Electrical	1.1	37.2	0.5	III	200	197	3	74.3	4.1	11.5	27.3	31.4
854160	Mounted piezo-electric crystals	Machinery / Electrical	1.1	29.1	0.6	III	158	156	2	58.0	1.4	7.5	26.0	23.1
481840	Sanitary articles of paper, sanitary towels, diapers	Wood & wood products	1.1	11.1	0.1	II	132	124	8	34.9	-1.2	9.3	16.3	10.5
401110	Pneumatic tyres new of rubber for motor cars	Plastics / Rubbers	1.0	4.2	0.3	III	270	261	9	78.9	-1.3	16.2	39.2	24.7

Note: ni refers to the number of significant RRIs.

Annex C.

Table C.1. Densities for top 50 exported products

Ranking by density

ID	Product	Category	RCA	Exports Share %	Density	Opport. Value
190590	Communion wafers, rice paper, bakers wares	Foodstuffs	2.7	0.3	44.6	-0.5
392330	Plastic carboys, bottles and flasks, etc.	Plastics / Rubbers	5.6	0.3	39.3	-0.8
401693	Gaskets, washers and other seals of vulcanised rubber	Plastics / Rubbers	7.8	0.6	33.6	0.4
392690	Plastic articles	Plastics / Rubbers	2.8	1.0	31.9	0.5
210690	Food preparations	Foodstuffs	13.6	2.9	31.6	-0.4
854459	Electric conductors, 80-1,000 volts, no connectors	Machinery / Electrical	5.3	0.8	29.1	-0.6
190530	Sweet biscuits, waffles and wafers	Foodstuffs	4.6	0.3	26.8	-1.0
210390	Sauces, mixed condiments, mixed seasoning	Foodstuffs	10.8	0.6	21.0	-0.7
300490	Medicaments, in dosage	Chemicals & Allied Industries	0.6	1.1	21.0	0.4
300210	Antisera and other blood fractions	Chemicals & Allied Industries	1.2	0.7	20.8	1.0
853669	Electrical plugs and sockets	Machinery / Electrical	8.7	0.9	19.5	0.5
60299	Plants, live (including their roots),nes	Agriculture	9.5	0.4	19.1	-0.8
851220	Lighting/visual signalling equipment nes	Machinery / Electrical	3.7	0.4	18.8	0.5
90111	Coffee, not roasted, not decaffeinated	Agriculture	21.3	2.7	18.4	-2.9
853690	Electrical switch, protector, connecter for < 1kV nes	Machinery / Electrical	1.7	0.3	18.1	0.3
701090	Glass containers nes for packing or conveyance goods	Stone / Glass	9.8	0.5	17.9	-0.9
40120	Milk not concentrated nor sweetened 1-6% fat	Animal & Animal Products	9.6	0.3	17.3	-0.6
392321	Sacks & bags (including cones) of polymers of ethylen	Plastics / Rubbers	4.2	0.3	17.2	-1.1
902190	Orthopaedic appliances, nes	Instruments	10.9	0.8	16.2	0.6
401110	Pneumatic tyres new of rubber for motor cars	Plastics / Rubbers	4.2	1.0	16.0	0.0
870850	Drive axles with differential for motor vehicles	Transportation	2.1	0.3	15.8	0.6
901819	Electro-diagnostic apparatus, nes	Instruments	3.3	0.4	14.2	1.1
902130	Artificial body parts, aids and appliances, etc	Instruments	50.9	3.3	13.8	1.2
80430	Pineapples, fresh or dried	Agriculture	726.3	9.6	13.1	-2.3
854800	Electrical parts of machinery and apparatus, nes	Machinery / Electrical	37.2	1.1	12.8	0.2
901890	Instruments, appliances for medical, etc science, nes	Instruments	29.8	8.7	12.4	0.4
200940	Pineapple juice, not fermented or spirited	Foodstuffs	255.7	1.3	12.2	-1.7
847330	Parts and accessories of data processing equipment ne	Machinery / Electrical	2.0	1.3	11.2	0.2
854219	Monolithic integrated circuits, except digital	Machinery / Electrical	2.3	6.6	11.1	0.4
170111	Raw sugar, cane	Foodstuffs	9.6	0.7	10.8	-2.3
900791	Parts and accessories for cinematographic cameras	Instruments	148.4	0.4	10.8	0.5
854441	Electric conductors, nes < 80 volts, with connectors	Machinery / Electrical	2.3	0.4	10.7	-1.2
151110	Palm oil, crude	Agriculture	10.6	0.7	10.2	-2.7
60491	Foliage,branches, for bouquets, etc. - fresh	Agriculture	56.4	0.3	9.7	-1.3
841810	Combined refrigerator-freezers, two door	Machinery / Electrical	3.6	0.3	9.4	-0.3
80300	Bananas, including plantains, fresh or dried	Agriculture	130.0	9.8	9.4	-2.5
854160	Mounted piezo-electric crystals	Machinery / Electrical	29.1	1.1	9.3	0.3

151190	Palm oil or fractions simply refined	Agriculture	2.5	0.3	8.8	-2.5
481840	Sanitary articles of paper, sanitary towels, diapers	Wood & wood products	11.1	1.1	8.6	-0.2
80710	Melons (including watermelons), fresh	Agriculture	50.5	0.9	7.6	-1.9
901839	Needles, catheters, cannulae etc, (medical)	Instruments	43.2	6.4	7.6	0.0
611592	Hosiery nes, of cotton, knit	Textiles	9.0	0.3	7.6	-1.9
852990	Parts for radio/tv transmit/receive equipment, nes	Machinery / Electrical	0.9	0.3	7.5	-0.2
71490	Arrowroot, salep, etc fresh or dried and sago pith	Agriculture	103.1	0.3	6.9	-2.3
81190	Fruits and nuts (uncooked, steamed, boiled) frozen,ne	Agriculture	38.9	0.6	6.9	-1.0
30410	Fish fillet or meat, fresh or chilled, not liver, roe	Animal & Animal Products	12.8	0.4	5.9	-1.2
200899	Fruit, edible plants nes otherwise prepared/preserved	Foodstuffs	34.6	0.7	5.6	-1.4
392112	Sheet etc, cellular of polymers of vinyl chloride	Plastics / Rubbers	29.0	0.3	5.4	0.2
71410	Manioc (cassava), fresh or dried	Agriculture	37.5	0.6	4.7	-3.0
20230	Bovine cuts boneless, frozen	Animal & Animal Products	3.7	0.4	4.2	-0.9

Annex D.

Table D.1. List of Upscale opportunities for Costa Rica (densities above 5)

ID	Product	Density	Opportunity Value
491110	Trade advertising material, catalogues etc.	35.3	0.11
490290	Newspapers, journals and periodicals, < 4 issues/week	30.6	0.19
330530	Hair lacquers	29.9	0.36
732690	Articles of iron or steel, nes	29.7	0.35
843280	Rollers, soil preparation, cultivation machinery, nes	28.7	0.23
730890	Structures and parts of structures, iron or steel, ne	26.8	0.12
392520	Plastic doors and windows and frames thereof	26.8	0.05
843139	Parts of lifting/handling machinery nes	25.8	0.80
843390	Parts of agricultural machinery	25.0	0.80
392190	Plastic sheet, film, foil or strip, nes	24.8	0.24
843699	Parts agricultural, forestry, bee-keeping machines ne	24.6	0.82
841490	Parts of vacuum pumps, compressors,fans,blowers,hoods	23.7	0.93
381600	Refractory cements, mortars, concretes except graphit	23.2	0.41
940390	Furniture parts nes	23.0	0.01
382100	Prepared culture media for developing micro-organisms	22.8	1.07
870892	Mufflers and exhaust pipes for motor vehicles	22.6	0.60
392630	Plastic fittings for furniture, coachwork, etc	22.3	0.59
400829	Rods, profile shapes of vulcanised non-cellular rubbe	22.3	0.29
841899	Parts of refrigerating or freezing equipment	22.2	0.19
843120	Parts of fork-lift etc trucks	22.1	0.72
871690	Trailer/non-mechanically propelled vehicle parts nes	22.1	0.42
871639	Trailers nes for the transport of goods	21.9	0.46
731829	Non-threaded articles of iron or steel, nes	21.9	1.09
392113	Sheet etc, cellular of polyurethane	21.8	0.51
870899	Motor vehicle parts nes	21.5	0.43
840390	Parts of central heating boiler nes	21.4	0.27
320990	Polymer based paints & varnishes nes, aqueous medium	21.2	0.19
870829	Parts and accessories of bodies nes for motor vehicle	21.1	0.62
560210	Needleloom felt and stitch-bonded fibre fabric	21.0	0.19
300490	Medicaments nes, in dosage	21.0	0.38
843149	Parts of cranes, work-trucks, shovels, constr machine	20.9	0.49
870839	Brake system parts except linings for motor vehicles	20.9	0.74
842199	Parts for filter/purifying machines for liquid/gas	20.7	1.03
400950	Rubber tube, pipe or hose with fittings	20.5	0.60
400930	Rubber tube, pipe, hose textile-reinforced no fitting	20.5	0.66
841950	Heat exchange units, non-domestic, non-electric	20.2	0.62
842123	Oil/petrol filters for internal combustion engines	20.1	0.41
840999	Parts for diesel and semi-diesel engines	19.9	0.37
841583	Air conditioners nes, without refrigerating unit	19.6	0.61
401695	Rubber articles, inflatable nes, vulcanised rubber	19.5	0.07
841480	Air or gas compressors, hoods	19.3	1.04
392111	Sheet etc, cellular of polymers of styrene	19.0	0.14

848120	Valves for oleohydraulic or pneumatic transmissions	19.0	1.18
340319	Lubricating oil etc containing <70% petroleum oil nes	19.0	0.77
843290	Parts for soil preparation or cultivation machinery	19.0	0.33
481190	Paper, coated/impregnated/covered/coloured/printed ne	18.7	0.74
160249	Swine meat or offal nes, prepared,preserved, not live	18.7	0.29
400811	Plate, sheet, strip of vulcanised cellular rubber	18.7	0.27
841790	Parts of industrial or laboratory furnaces/ovens	18.7	0.13
853080	Electric signal, safety & traffic controls, nes	18.6	0.51
392290	Bathroom wares nes, of plastics	18.5	0.08
330430	Manicure or pedicure preparations	18.3	0.12
180631	Chocolate, cocoa preps, block, slab, bar, filled, >2k	18.3	0.04
700721	Safety glass (laminated) for vehicles, aircraft, etc	18.2	0.13
330710	Pre-shave, shaving and after shaving preparations	18.2	0.06
850490	Parts of electrical transformers and inductors	18.2	0.23
820830	Blades for kitchen appliances & food industry machine	18.1	0.99
852490	Sound recordings other than photographic products nes	17.9	1.11
700800	Multiple-walled insulating units of glass	17.9	0.22
731819	Iron or steel threaded articles except screw, nut,bol	17.8	0.88
701329	Drinking glasses, except lead crystal or glass cerami	17.7	0.25
844190	Parts of machinery for making pulp, paper or board	17.7	1.03
842131	Intake air filters for internal combustion engines	17.7	0.27
843229	Scarifiers, cultivators, weeders and hoes	17.6	0.30
382390	Chemical industry products, preparations, mixtures ne	17.5	0.97
400910	Rubber tube, pipe or hose not reinforced, no fittings	17.5	0.63
842290	Parts of wash, filling, closing, aerating machinery	17.4	0.52
681091	Prefabricated structural items of cement or concrete	17.4	0.27
842839	Continuous action elevators or conveyors for goods ne	17.3	0.95
732490	Sanitary ware and parts thereof, iron or steel, nes	17.1	0.20
843320	Hay etc mowers and cutter bars, tractor mounting	17.0	0.70
482319	Paper, gummed, adhesive nes, cut to size, strip, roll	17.0	0.37
847790	Parts of machines for working rubber or plastic	16.9	1.38
847982	Machines to mix, knead, crush, grind, etc, nes	16.9	0.99
732183	Domestic iron/steel solid fuel appliances, not cooker	16.8	0.11
840991	Parts for spark-ignition engines except aircraft	16.8	0.63
300290	Blood, toxins, cultures, medical use, nes	16.7	0.53
732510	Cast articles, of non-malleable cast iron nes	16.6	0.06
844250	Printing type, blocks, plates, cylinders etc	16.6	0.58
848360	Clutches, shaft couplings, universal joints	16.5	1.46
842430	Steam or sand blasting machines	16.4	0.80
848190	Parts of taps, cocks, valves or similar appliances	16.4	0.74
842121	Water filtering or purifying machinery or apparatus	16.1	0.70
848180	Taps, cocks, valves and similar appliances, nes	16.0	0.92
300390	Medicaments nes, formulated, in bulk	15.8	0.36
841710	Furnaces/ovens non-electric for ores/pyrites/metals	15.8	0.48
860799	Railway rolling stock parts nes	15.7	0.79
901850	Ophthalmic instruments and appliances	15.7	1.12
700711	Safety glass (tempered) for vehicles, aircraft, etc	15.5	0.29
180632	Chocolate, cocoa prep, block/slab/bar, not filled,>2k	15.5	0.04
482311	Paper, self-adhesive, cut to size, in strips or rolls	15.5	0.62
841391	Parts of pumps for liquids	15.4	0.90
853890	Parts, electric switches, protectors & connectors nes	15.4	0.53

21012	Bellies (streaky) of swine, salted, dried or smoked	15.3	0.90
846599	Machine tools for wood, cork or hard plastic, etc nes	15.3	0.50
841920	Medical, surgical or laboratory sterilizers	15.3	0.88
848350	Flywheels and pulleys including pulley blocks	15.2	1.11
870891	Radiators for motor vehicles	15.1	0.39
721229	Flat rolled steel, <600mm, electro-plated zinc, nes	15.1	0.62
853649	Electrical relays for 60 - 1,000 volts	15.0	0.16
870332	Automobiles, diesel engine of 1500-2500 cc	15.0	0.73
820559	Tools for masons/watchmakers/miners, hand tools nes	15.0	1.05
843810	Bakery and pasta making machinery	14.9	0.52
845190	Parts of machines for treating textile fabrics	14.9	0.28
850164	AC generators, of an output > 750 kVA	14.9	0.35
841630	Mechanical stokers, grates, ash dischargers, etc	14.8	0.54
853090	Electric signal, safety & traffic controller parts	14.8	0.58
842820	Pneumatic elevators and conveyors	14.7	0.43
680510	Abrasive powderor grain on woven textile support	14.7	1.00
850153	AC motors, multi-phase, of an output > 75 kW	14.7	0.72
846792	Pneumatic hand tool parts	14.6	1.53
401099	Conveyor, transmission belts and belting, rubber nes	14.6	0.62
391690	Monofilament(>1mm), rods,not ethylene or vinyl polyme	14.5	0.36
842890	Lifting, handling, loading or unloading machinery nes	14.5	1.25
732090	Springs, iron or steel, except helical/leaf	14.5	0.43
820790	Screwdriver bits and other interchangeable tools	14.5	1.37
851660	Electric cooking, grilling & roasting equipment nes	14.4	0.10
321519	Printing ink, other than black	14.3	0.43
841690	Parts of furnace burners, associated equipment	14.3	0.30
846510	Multi-purpose machines for wood etc work	14.3	0.40
851190	Parts of electrical ignition or starting equipment	14.1	0.39
842490	Parts for sprays and powder dispersers	14.1	0.49
903290	Parts and accessories for automatic controls	14.0	0.85
940310	Office furniture, metal, nes	14.0	0.09
830242	Mountings, fittings, of base metal, for furniture, ne	13.8	0.67
902790	Microtomes, parts of scientific analysis equipment	13.8	1.74
850230	Electric generating sets, nes	13.8	0.53
903289	Automatic regulating/controlling equipment nes	13.7	0.85
853710	Electrical control and distribution boards, < 1kV	13.7	0.17
902680	Equipment to measure, check gas/liquid properties nes	13.6	1.14
830210	Hinges of base metal	13.6	0.22
903220	Manostats	13.5	0.80
490110	Brochures, leaflets and similar, in single sheets	13.5	0.19
310240	Ammonium nitrate limestone etc mixes, pack >10 kg	13.4	0.17
382200	Composite diagnostic or laboratory reagents, nes	13.3	0.99
320419	Synthetic organic colouring matter nes	13.3	0.67
841840	Freezers of the upright type, < 900 litre capacity	13.3	0.09
840820	Engines, diesel, for motor vehicles	13.2	0.84
846692	Parts, accessories nes, wood, plastic machine tools	13.2	0.92
870331	Automobiles, diesel engine of <1500 cc	13.2	0.28
842240	Packing or wrapping machinery nes	13.2	0.69
830160	Lock parts, etc, of base metal,	13.2	0.33
851290	Parts of cycle & vehicle light, signal, etc equipment	13.1	0.19
841350	Reciprocating positive displacement pumps nes	13.1	0.78

842699	Cranes or derricks nes	13.0	0.12
843131	Parts of lifts, skip hoist or escalators	13.0	0.45
850152	AC motors, multi-phase, of an output 0.75-75 kW	13.0	0.57
350510	Dextrins and other modified starches	12.9	0.47
940120	Seats, motor vehicles	12.9	0.23
851680	Electric heating resistors	12.9	0.48
843490	Parts of milking machines and dairy machinery	12.8	0.75
870810	Bumpers and parts thereof for motor vehicles	12.8	0.94
903300	Parts/accessories nes for optical/electric instrument	12.8	0.47
848390	Parts of power transmission etc equipment	12.7	1.25
731590	Chain parts, iron or steel, except articulated link	12.7	0.93
680690	Mineral heat or sound insulating materials & articles	12.6	1.21
841360	Rotary positive displacement pumps nes	12.6	0.93
843680	Agricultural, bee-keeping plant nes, germination plan	12.6	0.79
848340	Gearing, ball screws, speed changers, torque converte	12.5	1.56
820730	Tools for pressing, stamping or punching	12.5	0.89
846291	Hydraulic presses for working metal	12.5	1.12
851690	Parts of electro-thermic apparatus, domestic, etc	12.5	0.22
680422	Grindstones etc, agglomerated abrasives or ceramics	12.5	0.57
560300	Nonwovens textiles except felt	12.5	0.45
848110	Valves, pressure reducing	12.5	0.73
850990	Parts of domestic appliances with electric motor	12.5	0.13
840310	Central heating boilers nes	12.4	0.47
721129	Hot rolled iron or non-alloy steel, width <600mm unclad, nes	12.4	0.37
843999	Parts of machines for making paper or paperboard	12.4	0.89
842833	Continuous action goods conveyor or elevator belt typ	12.4	0.46
903210	Thermostats	12.2	0.36
851531	Automatic electric plasma, other arc welding equipmen	12.2	1.08
940290	Medical, dental, surgical & veterinary furniture, nes	12.2	0.50
848590	Machinery parts, non-electrical, nes	12.1	1.22
902710	Gas/smoke analysis apparatus	12.0	1.31
846694	Parts, accessories nes, metal shaping machine tools	12.0	0.71
847930	Presses for particle, fibre board, etc manufacture	12.0	0.26
391990	Self-adhesive plates, sheets, film, plastic, w >20 cm	12.0	1.61
902610	Equipment to measure or check liquid flow or level	11.9	1.20
845090	Parts of household or laundry-type washing machines	11.9	0.39
841370	Centrifugal pumps nes	11.9	0.73
870894	Steering wheels, columns & boxes for motor vehicles	11.7	0.34
350520	Glues based on starches, or modified starches	11.7	0.33
830241	Mountings, fittings, of base metal, for buildings, ne	11.7	0.03
902290	Parts and accessories for radiation apparatus	11.7	1.69
842211	Dish washing machines (domestic)	11.7	0.57
760612	Aluminium alloy rectangular plate/sheet/strip,t >0.2m	11.7	0.47
842691	Cranes designed for mounting on road vehicles	11.7	0.63
481140	Paper, coat/impregnated with wax/stearin/glycerol, ne	11.7	0.27
902620	Equipment to measure or check pressure	11.6	0.97
841861	Compression refrigeration equipment with heat exchang	11.6	0.95
846890	Welding machinery parts	11.6	0.41
680800	Boards, etc of veg fibre with mineral binder or cemen	11.6	0.17
441830	Parquet panels and tiles, of wood	11.6	0.04
842720	Self-propelled works trucks, non-electric	11.6	1.55

850131	DC motors, DC generators, of an output < 750 watts	11.5	0.79
843330	Hay tedders and rakes and other haymaking machinery	11.5	0.99
732020	Springs, helical, iron or steel	11.5	1.06
841939	Non-domestic, non-electric dryers nes	11.5	0.94
391190	Polysulphides, polysulphones etc, nes in primary form	11.5	1.31
843110	Parts of hoists and winches	11.5	0.56
390690	Acrylic polymers nes, in primary forms	11.4	1.10
848130	Valves, check	11.4	0.96
851410	Industrial electric resistance heated furnaces & oven	11.3	1.52
902480	Machines for testing mechanical properties nes	11.3	0.97
340399	Lubricating preparations, zero petroleum content, nes	11.3	1.32
902000	Breathing appliances and gas masks	11.3	0.42
731821	Washers, spring or lock, iron or steel	11.2	1.22
842489	Sprays/powder dispersing machines except agricultural	11.2	1.36
391739	Plastic tube, pipe or hose, flexible, nes	11.2	0.18
902750	Instruments nes using optical radiations	11.2	1.50
841919	Instantaneous/storage water heaters, not electric nes	11.2	0.34
731815	Bolts/screws nes, with/without nut/washer, iron/steel	11.1	0.83
680610	Slag wool, rock wool, similar wools, bulk, sheet, rol	11.1	0.69
841990	Parts, laboratory/industrial heating/cooling machiner	11.1	0.44
480253	Paper, fine, woodfree, >150 g/m2, uncoated, nes	11.1	0.86
901849	Instruments and appliances, used in dentistry	11.1	1.09
320649	Inorganic colouring matter nes, including preparation	11.0	0.26
870790	Bodies for tractors, buses, trucks etc	10.9	0.43
847990	Parts of machines and mechanical appliances nes	10.9	1.54
300590	Medical dressings etc except those with adhesive laye	10.9	0.36
902730	Spectrometers, spectrophotometers, etc using light	10.9	1.48
841780	Industrial furnace, oven, incinerator non-electric ne	10.8	0.12
846239	Shearing (except punch-shear) machine tools, nes	10.8	0.87
846799	Hand held tools nes, parts thereof	10.7	1.11
846150	Metal sawing or cutting-off machines	10.7	0.80
330420	Eye make-up preparations	10.7	0.75
853010	Electric signal, safety & traffic controls, railway	10.7	0.76
300439	Hormones nes, except contraceptives, in dosage	10.6	0.94
902780	Equipment for physical or chemical analysis, nes	10.6	1.50
20312	Swine hams, shoulders & cuts bone in, fresh or chille	10.5	1.10
851430	Industrial/laboratory electric furnaces and ovens nes	10.5	0.84
870870	Wheels including parts/accessories for motor vehicles	10.5	0.48
300610	Suture materials, sterile surgical and dental goods	10.5	0.74
40130	Milk and cream not concentrated nor sweetened < 6% fa	10.5	0.21
848079	Moulds for rubber or plastic, nes	10.5	0.13
841199	Parts of gas turbine engines except turbo-jet/prop	10.4	1.12
846693	Parts, accessories nes, metal cutting machine tools	10.4	1.16
820770	Tools for milling	10.4	1.46
841231	Pneumatic power engines/motors, linear acting	10.4	1.45
852610	Radar apparatus	10.4	0.73
860721	Air brakes, parts for railway rolling stock	10.3	0.69
851782	Telegraphic apparatus, nes	10.3	0.50
847989	Machines and mechanical appliances nes	10.2	1.46
844240	Parts of machinery for print preparation	10.2	1.05
741999	Articles of copper, nes	10.2	0.64

847619	Automatic goods-vending machines, non-food	10.2	0.74
843850	Machinery for the preparation of meat and poultry	10.2	0.57
903081	Electrical measurement recording instruments	10.2	0.55
401091	Conveyor belts and belting, rubber, <20cm wide	10.2	0.45
846229	Machine tools to bend, fold, shear or press metal, ne	10.2	0.60
730729	Pipe fittings of stainless steel except butt welding	10.1	0.83
491191	Pictures, designs and photographs	10.1	0.23
848140	Valves, safety or relief	10.1	0.91
590699	Rubberised woven textile fabric, except adhesive tape	10.1	0.65
842420	Spray guns and similar appliances	10.1	1.30
760820	Tubes and pipe, aluminium alloy	9.9	0.21
40210	Milk powder < 1.5% fat	9.9	0.09
853590	Electrical apparatus for voltage > 1kV, nes	9.9	0.64
848210	Bearings, ball	9.9	0.40
902490	Parts and accessories of material testing equipment	9.9	0.89
903180	Measuring or checking equipment, nes	9.8	1.10
841620	Furnace burners for solid, gas or combination fuel	9.8	0.91
847490	Parts for mineral sort, screen, mix, etc machines	9.7	0.03
960350	Brushes nes, as parts of machines, appliances etc	9.7	0.55
846591	Sawing machines for working wood, cork, etc	9.7	0.66
902111	Artificial joints	9.7	1.63
400819	Rod and profile shapes of vulcanised cellular rubber	9.7	0.60
903190	Parts and access for measuring, checking equipment ne	9.6	0.87
841460	Ventilating hoods having a maximum width < 120 cm	9.6	0.12
848041	Moulds, injection or compression, for metals/carbides	9.6	0.67
40410	Whey	9.5	0.39
830249	Mountings, fittings, of base metal, nes	9.5	0.24
846620	Work holders for use with machine tools	9.5	1.07
848071	Moulds, injection & compression, for rubber or plasti	9.5	1.12
902211	Medical X-ray apparatus	9.5	1.50
790790	Articles of zinc nes	9.4	0.10
852290	Parts and accessories of recorders except cartridges	9.4	0.25
761610	Aluminium nails, tacks, staples, bolts, nuts etc,	9.4	0.37
844849	Parts & accessories of looms, auxiliary machinery nes	9.4	0.94
390730	Epoxide resins, in primary forms	9.4	1.75
731816	Nuts, iron or steel	9.4	1.38
830230	Motor vehicle mountings, fittings, of base metal, nes	9.4	0.46
851180	Glow plugs & other ignition or starting equipment nes	9.3	0.63
870390	Automobiles nes including gas turbine powered	9.3	0.80
870840	Transmissions for motor vehicles	9.3	0.89
848060	Moulds for mineral materials	9.2	0.49
841330	Fuel, lubricating and cooling pumps for motor engines	9.2	0.90
841229	Hydraulic power engines/motors, except linear acting	9.2	0.34
841869	Refrigerating or freezing equipment nes	9.2	0.40
701920	Woven fabric of glass fibres	9.1	0.50
848299	Bearing parts, nes	9.1	0.44
854380	Electrical machines and apparatus, nes	9.1	1.25
870322	Automobiles, spark ignition engine of 1000-1500 cc	9.1	0.29
852691	Radio navigational aid apparatus	9.0	0.87
20319	Swine cuts, fresh or chilled, nes	9.0	0.91
846610	Tool holders, self-opening dieheads, for machine tool	9.0	1.01

731822	Washers, iron or steel, except spring/lock	9.0	0.87
850980	Domestic appliances, with electric motor, nes	9.0	0.37
391520	Polystyrene waste or scrap	9.0	0.19
390390	Polymers of styrene except SAN or ABS in primary form	9.0	0.96
750712	Tubes and pipe, nickel alloy	8.9	1.55
848320	Bearing housings etc incorporating ball/roller bearin	8.9	1.02
401010	Transmission belts etc, rubber, trapezoidal	8.9	0.69
940510	Chandeliers, other electric ceiling or wall lights	8.9	0.37
846789	Tools for working in hand, non-electric motor nes	8.9	0.84
390799	Polyesters nes, in primary forms	8.9	1.06
591110	Textile fabric for card clothing, technical use	8.8	1.12
853180	Electric sound or visual signalling apparatus, nes	8.8	0.18
761100	Aluminium reservoirs,vats, tanks, etc, volume >300l	8.8	0.52
721122	Hot rolled iron or non-alloy steel, width <600mm, t >4.75mm, unclad nes	8.8	0.33
847780	rubber or plastic working machines, nes	8.8	1.22
300640	Dental cements and other dental fillings, bone cement	8.7	0.91
940592	Lamp and lighting fitting parts of plastics	8.7	0.64
350710	Rennet and concentrates thereof	8.6	0.20
854290	Parts of electronic integrated circuits etc	8.6	0.72
851140	Starter motors	8.6	0.77
391000	Silicones in primary forms	8.6	1.54
850810	Drills, hand-held, with self-contained electric motor	8.6	0.66
400510	Compounded (carbon black, silica) unvulcanised rubber	8.6	0.53
848490	Gasket sets, other joints of similar composition	8.5	0.73
841989	Machinery for treatment by temperature change nes	8.5	1.08
903039	Ammeters, voltmeters, ohm meters, etc, non-recording	8.5	0.84
852692	Radio remote control apparatus	8.4	0.09
842091	Cylinders for rolling machines, except metals, glass	8.4	0.44
382000	Anti-freezing preps and prepared de-icing fluids	8.4	0.41
293690	Vitamin concentrates, intermixtures of vitamins	8.4	0.61
722590	Flat rolled alloy-steel, width >600mm, nes	8.4	1.33
843610	Machinery for preparing animal feeding stuffs	8.4	0.51
340213	Non-ionic surface active agents	8.4	1.10
722210	Stainless steel bar nfw than hot rolled/drawn/extrude	8.4	0.59
841090	Parts of hydraulic turbines and water wheels	8.4	0.26
870421	Diesel powered trucks weighing < 5 tonnes	8.4	0.05
210310	Soya sauce	8.4	0.11
843230	Seeders, planters and transplanters	8.3	0.26
842129	Filtering/purifying machinery for liquids nes	8.3	1.11
843360	Machines for cleaning, sorting, grading eggs/fruit/et	8.3	0.19
840890	Engines, diesel except motor vehicle/marine	8.3	0.70
903120	Test benches for measuring or checking equipment	8.3	1.02
741539	Copper screw hooks and similar articles	8.3	0.58
848049	Moulds for metal or metal carbides, nes	8.3	0.31
830120	Locks of a kind used for motor vehicles of base metal	8.3	0.53
390950	Polyurethanes in primary forms	8.2	0.80
842519	Pulley tackle/hoists not skip/vehicle/electric hoists	8.2	0.65
841290	Parts of hydraulic/pneumatic/other power engines	8.2	0.44
330410	Lip make-up preparations	8.2	0.88
392051	Sheet/film not cellular/reinf polymethyl methacrylate	8.2	0.84
841221	Hydraulic power engines/motors, linear acting	8.2	0.75

480560	Paper, weighing 150 g/m2 or less, uncoated, nes	8.1	0.02
902300	Instruments, apparatus and models, for demonstration	8.1	0.66
851150	Generators and alternators	8.1	0.33
870120	Road tractors for semi-trailers (truck tractors)	8.0	0.97
870190	Wheeled tractors nes	8.0	0.52
854129	Transistors, except photosensitive, > 1 watt	8.0	0.44
853224	Electric capacitors, fixed, ceramic, multilayer,	8.0	0.71
848330	Bearing housings, shafts, without ball/roller bearing	8.0	0.78
842549	Jacks and hoists except hydraulic and garage hoists	8.0	0.12
854520	Carbon and graphite brushes	8.0	0.98
853223	Electric capacitors, fixed, ceramic, single layer	8.0	0.04
854150	Semiconductor devices, not light sensitive or emittin	8.0	1.03
880330	Aircraft parts nes	8.0	0.04
731512	Chain, articulated link, iron or steel, except roller	8.0	1.01
850590	Electro-magnets nes and parts of magnetic devices	8.0	0.61
854121	Transistors, except photosensitive, < 1 watt	8.0	0.89
854690	Electrical insulators, except glass/ceramics	8.0	0.39
481011	Paper, fine, woodfree, <150 g/m2, clay coated	8.0	0.96
820299	Saw blades nes, including stone cutting, etc	8.0	1.00
280800	Nitric acid, sulphonitric acids	8.0	0.14
845150	Machinery to reel, fold, cut, pink, etc textile fabri	7.9	0.58
721711	Wire, iron or non-alloy steel, not plated or coated, <0.25%C	7.9	0.05
843141	Buckets, shovels, grabs etc for excavating machinery	7.9	0.29
391910	Self-adhesive plastic, rolls <20cm wide	7.8	0.43
903089	Electrical measurement instruments nes	7.8	1.46
853190	Parts of electric sound & visual signalling apparatus	7.7	0.57
850880	Tools, hand-held, with electric motor, not drills/saw	7.7	1.05
900220	Optical filters	7.7	0.23
820231	Circular saw blades, working part of steel	7.7	0.96
846592	Planing and milling machines for wood, cork, etc	7.7	0.52
841981	Commercial equipment, hot drinks/cooking/heating food	7.6	0.96
722090	Rolled stainless steel sheet, width < 600mm, nes	7.6	1.21
854110	Diodes, except photosensitive and light emitting	7.6	0.56
851490	Parts of industrial/etc electric furnaces/ovens nes	7.6	0.84
847759	rubber or plastic moulding and forming machines nes	7.5	0.36
170210	Lactose and lactose syrup	7.5	0.60
681599	Articles of stone or of other mineral substances nes	7.5	0.15
900211	Objective lenses for cameras, projectors, etc	7.5	0.36
843240	Manure spreaders and fertilizer distributors	7.4	0.32
820220	Band saw blades	7.4	1.19
730722	Threaded elbows, bends and sleeves of stainless steel	7.4	1.31
841459	Electric fans, motor > 125 watts	7.4	0.34
831130	Coated rods/cored wire for flame solder/braze/weld	7.4	1.03
10119	Horses, live except pure-bred breeding	7.4	0.03
902720	Chromatographs, electrophoresis instruments	7.4	1.52
900190	Prisms, mirrors and optical elements nes, unmounted	7.4	0.21
321511	Printing ink, black	7.3	0.62
903040	Gain, /distortion and crosstalk meters, etc	7.3	1.31
970110	Paintings/drawings/pastels executed by hand	7.3	0.39
350400	Peptones, proteins and derivatives, nes, hide powder	7.3	0.55
730799	Fittings, pipe or tube, iron or steel, nes	7.3	0.67

841582	Air conditioners nes, with refrigerating unit	7.2	0.48
390810	Polyamide-6, -11, -12, -6,6, -6,9, -6,10 or -6,12	7.2	1.07
871150	Motorcycles, spark ignition engine of > 800 cc	7.2	1.14
750620	Plates, sheet, strip and foil, nickel alloy	7.1	1.85
848410	Gaskets of metal sheeting, including sandwich type	7.1	0.64
830170	Keys, including blanks for keys, of base metal	7.1	0.59
848310	Transmission shafts and cranks, cam and crank shafts	7.1	0.59
820890	Blades for leather, paper, tobacco etc. industries	7.1	0.39
820820	Blades for wood working machines	7.1	0.63
845899	Lathes nes for removing metal	7.0	0.53
851130	Distributors and ignition coils	7.0	0.53
391610	Monofilament(>1mm), rods, etc, ethylene polymers	7.0	0.11
843420	Dairy machinery	7.0	0.03
901820	Ultra-violet or infra-red ray apparatus	7.0	0.62
841410	Vacuum pumps	7.0	1.12
970200	Original engravings, prints and lithographs	7.0	1.21
870422	Diesel powered trucks weighing 5-20 tonnes	6.9	0.60
294190	Antibiotics nes, in bulk	6.9	0.70
741220	Pipe & tube fittings, of copper alloys	6.9	0.64
820232	Circular saw blades, working part other than steel	6.9	0.91
390590	Vinyl polymers, halogenated olefins, primary form, ne	6.9	1.59
960899	Duplicating stylos, pen/pencil holders, pen parts	6.9	1.02
844390	Parts of printing machinery and ancillary equipment	6.9	0.19
721230	Flat rolled iron or non-alloy steel, <600mm, coated with zinc, nes	6.9	0.06
700600	Cast, drawn or float glass sheet, edge worked or bent	6.9	0.68
847340	Parts and accessories of office machines, nes	6.9	0.34
842810	Lifts and skip hoists	6.8	0.23
731824	Cotters and cotter-pins, iron or steel	6.8	0.52
847199	Automatic data processing machines and units, nes	6.8	0.80
848220	Bearings, tapered roller, including assemblies	6.8	0.87
847193	Computer data storage units	6.8	0.81
482320	Paper, filter, cut to size or shape	6.8	0.66
847410	Machines to sort, screen, wash stone, ores & minerals	6.8	0.36
902690	Parts of equipment to measure or check fluid variable	6.8	1.00
901480	Navigational instruments and appliances nes	6.8	0.81
842139	Filtering or purifying machinery for gases nes	6.7	0.77
21019	Swine meat, salted/dried/smoked not ham/shoulder/bell	6.7	0.63
870893	Clutches and parts thereof for motor vehicles	6.7	1.07
650610	Safety headgear	6.7	0.22
842119	Centrifuges nes	6.7	0.26
853540	Lightning arresters & voltage or surge limiters > 1kV	6.7	0.54
850120	Universal AC/DC motors of an output < 37.5 watts	6.7	0.11
847230	Machinery for processing mail of all kinds	6.7	1.13
121291	Sugar beet	6.6	0.32
846190	Metal cuttting, shaping, filing, engrave machines, ne	6.6	0.64
903140	Optical instruments and appliances, nes	6.6	1.66
902990	Parts and accessories of revolution counters, etc	6.6	0.25
902920	Speed indicators, tachometers, stroboscopes	6.6	0.69
842122	Filtering/purifying machinery/apparatus for beverages	6.6	0.44
722240	Angles, shapes and sections, stainless steel	6.6	0.78
480580	Paper, weighing 225 g/m2 or more, uncoated, nes	6.6	0.65

847329	Parts and accessories of accounting machines, nes	6.5	0.25
854140	Photosensitive/photovoltaic/LED semiconductor devices	6.5	1.05
400690	Rubber unvulcanised as rods, tubes, profiles, etc	6.5	0.54
870880	Shock absorbers for motor vehicles	6.5	0.84
381519	Supported catalysts, except nickel or precious metal	6.5	1.02
732410	Sinks and wash basins, stainless steel	6.5	0.05
901780	Instruments for measuring length, hand use, nes	6.5	1.05
392114	Sheet etc, cellular of regenerated cellulose	6.5	0.66
854211	Monolithic integrated circuits, digital	6.5	0.37
722020	Stainless steel sheet, w <600mm, cold rolled/reduced	6.5	1.23
870423	Diesel powered trucks weighing > 20 tonnes	6.4	0.64
843311	Mowers, powered, lawn, with horizontal cutting device	6.4	1.06
731823	Rivets, iron or steel	6.4	1.22
851850	Electric sound amplifier sets	6.4	0.20
400211	Styrene-butadiene rubber (SBR/XSBR) latex	6.3	0.77
850820	Saws, hand-held, with self-contained electric motor	6.3	1.08
850440	Static converters, nes	6.3	0.66
841430	Compressors for refrigerating equipment	6.3	0.92
902590	Parts and accessories for thermometers, etc	6.3	0.43
851790	Parts of line telephone/telegraph equipment, nes	6.2	0.13
901390	Parts and accessories of optical appliances nes	6.2	0.11
847191	Digital computer cpu with some of storage/input/outpu	6.2	0.89
853110	Burglar or fire alarms and similar apparatus	6.2	0.34
901030	Projection screens	6.2	0.56
300440	Alkaloids, derivs, no antibiotics, hormones, in dosag	6.2	0.12
880310	Aircraft propellers, rotors and parts thereof	6.2	0.08
846310	Draw-benches for bars, tubes, profiles wire etc	6.2	0.72
846593	Grinding, sanding, polishing machines for wood, et c	6.2	0.81
870333	Automobiles, diesel engine of >2500 cc	6.2	0.74
853530	Isolating and make-and-break switches, voltage >1 kV	6.1	0.43
560600	Chenille, loop whale, gimped (except metallised) yarn	6.1	0.09
846490	Machine tools nes for stone, ceramics and cold glass	6.1	0.06
20322	Hams, shoulders and cuts, of swine, bone in, frozen	6.1	0.42
20900	Pig and poultry fat, unrendered	6.1	0.03
842191	Parts of centrifuges, including centrifugal dryers	6.0	0.63
854790	Electrical insulating fittings except plastic/ceramic	6.0	0.35
900219	Objective lenses, nes	6.0	0.05
392042	Sheet/film not cellular/reinf flexible vinyl polymer	6.0	0.18
20649	Swine edible offal, frozen except livers	6.0	0.69
291560	Butyric acids, valeric acids, their salts & esters	6.0	0.87
854190	Parts of semiconductor devices and similar devices	6.0	1.05
846691	Parts, accessories nes, stone, ceramic machine tools	6.0	0.76
732429	Baths, iron or steel, except cast iron	6.0	0.02
840690	Parts of steam and vapour turbines	5.9	0.77
870321	Automobiles, spark ignition engine of <1000 cc	5.9	0.18
820750	Tools for drilling, other than for rock drilling	5.9	0.81
382310	Prepared binders for foundry moulds or cores	5.9	0.76
901730	Micrometers, callipers and gauges	5.9	1.36
722220	Stainless steel bar nfw than cold formed/cold finish	5.8	0.90
853222	Electric capacitors, fixed, aluminium electrolytic ne	5.8	0.60
850690	Parts of primary cells and primary batteries	5.8	0.48

847940	Rope or cable-making machines	5.8	0.24
851539	Non-automatic electric plasma and other arc welders	5.7	0.62
400610	Camel-back strips for retreading rubber tyres	5.7	0.56
854411	Insulated winding wire of copper	5.7	0.22
831000	Non-illuminated base metal sign plates, letter, numbe	5.7	0.16
853929	Filament lamps, except ultraviolet or infra-red, nes	5.7	0.28
391239	Cellulose ethers nes, in primary forms	5.7	1.81
390930	Amino-resins nes, in primary forms	5.7	1.25
490890	Transfers (decalcomanias), except vitrifiable	5.7	0.03
481139	Paper, coated, impregnated, covered with plastics, ne	5.7	0.22
851671	Electric coffee or tea makers, domestic	5.6	0.35
330499	Beauty, makeup and suntan preparations nes	5.6	0.02
390890	Polyamides nes, in primary forms	5.6	1.71
732290	Non-electric heaters (with fan), parts, of iron/steel	5.6	0.50
702000	Articles of glass, nes	5.6	0.54
330290	Mixed odoriferous substances - industrial use nes	5.6	0.46
740721	Bars, rods & profiles of copper-zinc base alloys	5.6	0.29
400821	Plate, sheet, strip of vulcanised non-cellular rubber	5.6	0.28
870821	Safety seat belts for motor vehicles	5.6	0.63
731589	Chain, iron or steel, nes	5.6	0.34
845430	Casting machines used in metallurgy, foundries	5.5	0.78
851120	Ignition magnetos, magneto-generators and flywheels	5.5	0.13
842511	Electric hoists (except skip and vehicle hoists)	5.5	0.85
293629	Vitamins nes, derivatives, unmixed	5.5	0.77
841590	Parts for air conditioners	5.5	0.31
870323	Automobiles, spark ignition engine of 1500-3000 cc	5.5	0.75
851440	Industrial induction/dielectric heating equipment nes	5.5	0.72
851420	Industrial electric induction, dielectric furnace/ove	5.5	1.05
853290	Parts of electrical capacitors	5.5	0.56
870919	Work trucks except electrically powered	5.5	0.53
741021	Foil of refined copper, backed, t < 0.15mm	5.5	0.61
820810	Blades for metal working machines	5.5	1.38
842539	Winches or capstans nes	5.5	0.01
852910	Aerials and aerial reflectors	5.5	0.00
350790	Enzymes nes, prepared enzymes nes, except rennet	5.5	0.38
480890	Paper crepe, crinkle, embossed, perforated, not kraft	5.5	0.10
901380	Optical devices, appliances and instruments, nes	5.4	1.54
851810	Microphones and stands thereof	5.4	0.33
830790	Tubing,flexible, with/without fittings,base metal nes	5.4	0.47
400940	Rubber tube, pipe or hose, reinforced nes, no fitting	5.4	0.29
854320	Signal generators	5.4	1.39
845130	Ironing machines and presses including fusing presses	5.4	0.03
730449	Stainless steel pipe or tubing, except cold rolled	5.3	0.96
722699	Flat rolled alloy-steel, <600mm wide, nes	5.3	1.15
291219	Acyclic aldehydes without other oxygen function, nes	5.3	1.12
481021	Paper, fine, lightweight coated	5.3	1.55
481099	Paper, clay coated, nes	5.2	0.25
390791	Polyesters nes, unsaturated, in primary forms	5.2	0.38
871140	Motorcycles, spark ignition engine of 500-800 cc	5.2	1.39
846299	Metal shaping presses, nes	5.2	0.79
20329	Swine cuts, frozen nes	5.2	0.42

901920	Therapeutic respiration apparatus	5.2	0.83
381190	Oil additives nes, oxidation, corrosion, gum inhibito	5.1	0.95
845290	Parts of sewing machines, nes	5.1	0.03
871499	Bicycle parts nes	5.1	0.44
960839	Fountain pens, stylograph pens and other pens, nes	5.1	0.81
721190	Flat rolled iron or non-alloy steel, width <600mm, unclad, nes	5.1	0.03
392059	Sheet/film not cellular/reinf acrylic polymers nes	5.1	0.88
853120	Indicator panels incorporating electronic displays	5.1	0.14
843621	Poultry incubators and brooders	5.1	0.17
843359	Harvesting machinery nes	5.0	0.40
160242	Swine shoulders & cuts thereof, prepared or preserved	5.0	0.09
590320	Fabric impregnated, coated, covered with polyurethane	5.0	0.58
853990	Parts of electric filament or discharge lamps	5.0	0.11
870324	Automobiles, spark ignition engine of >3000 cc	5.0	0.97
902230	X-ray tubes	5.0	1.34
911490	Clock or watch parts, nes	5.0	0.08
321590	Ink, other than printing ink	5.0	0.85
842710	Self-propelled works trucks, electric motor	5.0	1.45

Annex E.

Table E.1. Upscale opportunities by family of products

Machinery / Electrical

ID	Sub-sector	Upscale opport.
8421	Centrifuges, including centrifugal dryers; filtering or purifying machinery and apparatus for liquids or gases	9
8419	Machinery, plant or laboratory equipment for the treatment of materials by a process involving change of temperature (i.e. heating, cooking, etc.); instantaneous or storage water heaters, non-electric	7
8483	Transmission shafts (including cam and crank); bearing housings and plain shaft bearings, gears and gearing, ball screws, gear boxes, flywheels and pulleys, clutches	7
8481	Taps, cocks, valves and similar appliances for pipes, boiler shells, tanks, vats or the like, including pressure-reducing valves and thermostatically controlled valves	6
8433	Harvesting and threshing machinery, straw and fodder balers, grass or hay mowers; machines for cleaning, sorting or grading eggs, fruit or other agricultural produce, other than machinery of heading no 8437	6
8414	Air or vacuum pumps, air or other gas compressors and fans; ventilating or recycling hoods incorporating a fan whether or not fitted with filters	6
8511	Ignition or starting equipment; used for spark-ignition or compression-ignition internal combustion engines; generators and cut outs used in conjunction with such engines	6
8541	Diodes, transistors, similar semiconductor devices; including photovoltaic cells assembled or not in modules, panels, light emitting mounted piezo-electric crystals	6
8431	Machinery parts; used solely or principally with the machinery of heading no. 8425 to 8430	6
8466	Machine-tools; parts suitable for use with the machines of heading no. 8456 to 8465, work or tool holders, self-opening dieheads, dividing heads and other attachments	6

Plastics / Rubbers / Chemicals

ID	Sub-sector	Upscale opport.
3921	Plastic plates, sheets, film, foil and strip n.e.s. in chapter 39	4
4009	Tubes, pipes and hoses, of vulcanised rubber (other than hard rubber), with or without their fittings (eg joints, elbows, flanges)	4
4008	Plates, sheets, strip, rods and profile shapes, of vulcanised rubber other than hard rubber	4
3304	Cosmetic and toilet preparations; beauty, make-up and skin care preparations (excluding medicaments, including sunscreen or sun tan preparations), manicure or pedicure preparations	4
3004	Medicaments; (not goods of heading no. 3002, 3005 or 3006) consisting of mixed or unmixed products for therapeutic or prophylactic use, put up in measured doses or in forms or packings for retail sale	3
3920	Plastic plates, sheets, film, foil and strip; non-cellular and not reinforced, laminated, supported or similarly combined with other materials, n.e.s. in chapter 39	3
3215	Ink; printing, writing or drawing ink and other inks; whether or not concentrated or solid	3
3907	Polyacetals, other polyethers and epoxide resins, in primary forms; polycarbonates, alkyd resins, polyallyl esters and other polyesters, in primary forms	3
4010	Conveyor or transmission belts or belting, of vulcanised rubber	3

Metals

ID	Sub-sector	Upscale opport.
7318	Screws, bolts, nuts, coach screws, screw hooks, rivets, cotters, cotter-pins, washers (including spring washers) and similar articles, of iron or steel	8
8302	Base metal mountings, fittings and similar articles for furniture, doors, staircases, windows, trunks, chests etc, castors with mountings of base metal, automatic door closers of base metal	5
8208	Knives and cutting blades, for machines or for mechanical appliances	4
8202	Tools, hand; blades for saws of all kinds (including slitting, slotting or toothless blades)	4
8207	Tools, interchangeable; for hand tools, whether or not power-operated, or for machine tools (pressing, stamping, punching, drilling etc.), including dies for drawing or extruding metal, and rock drilling or earth boring tools	4
7211	Iron or non-alloy steel; flat-rolled products, width less than 600mm, not clad, plated or coated	3
7307	Tube or pipe fittings (e.g. couplings, elbows, sleeves), of iron or steel	3
7222	Stainless steel bars and rods, angles, shapes and sections	3
7315	Chain and parts thereof, of iron or steel	3
7324	Sanitary ware and parts thereof, of iron or steel	3
8301	Padlocks and locks (key, combination, electrically operated) of base metal; clasps and frames with clasps incorporating locks, of base metal, keys for any or the foregoing articles, of base metal	3

Miscellaneous

ID	Sub-sector	Upscale opport.
9027	Instruments and apparatus; for physical or chemical analysis (e.g. polarimeters, spectrometers), for measuring or checking viscosity, porosity, etc., for measuring quantities of heat, sound or light	6
9032	Regulating or controlling instruments and apparatus; automatic type	4
9031	Measuring or checking instruments, appliances and machines, n.e.s. or included in this chapter; profile projectors	4
9030	Instruments, apparatus for measuring, checking electrical quantities not meters of heading no. 9028; instruments, apparatus for measuring or detecting alpha, beta, gamma, x-ray, cosmic and other radiations	4
9026	Instruments, apparatus for measuring or checking the flow, level, pressure of liquids, gases (e.g. flow meters, heat meters etc.), not instruments and apparatus of heading no. 9014, 9015, 9028 or 9032	4
9018	Instruments and appliances used in medical, surgical, dental or veterinary sciences, including scintigraphic apparatus, other electro-medical apparatus and sight testing instruments	3
9022	X-ray, alpha, beta, gamma radiation apparatus; x-ray tubes, x-ray generators, high tension generators, control panels and desks, screens, examination or treatment tables, chairs and the like	3
9002	Lenses, prisms, mirrors and other optical elements, of any material, mounted, being parts or fittings for instruments or apparatus, other than such elements of glass not optically worked	3

Transportation

ID	Sub-sector	Upscale opport.
8708	Parts and accessories for motor vehicles of heading no. 8701 to 8705	12
8703	Motor cars and other motor vehicles; principally designed for the transport of persons (other than those of heading no. 8702), including station wagons and racing cars	8
8704	Vehicles; for the transport of goods	3

Wood & wood products

ID	Sub-sector	Upscale opport.
4810	Paper and paperboard, one or both sides coated with kaolin or other inorganic substances, with binder or not, no other coating, whether or not surface-coloured, surface-decorated or printed, in rolls or sheets	3
4823	Paper, paperboard, cellulose wadding and webs of cellulose fibres; cut to size or shape, articles of paper pulp, paper and paper-board, cellulose wadding or webs of cellulose fibres, n.e.s. in chapter 48	3
4811	Paper, paperboard, cellulose wadding and webs of cellulose fibres, coated, impregnated, covered, surface-coloured, decorated or printed, rolls or sheets, excluding goods of heading no. 4803, 4809, 4810 and 4818	3

Chapter 4. Misallocation and Productivity in Costa Rica[20]

Alonso Alfaro Ureña and Jonathan Garita Garita

This paper documents the effect of resource misallocation on Costa Rica's aggregate total factor productivity (TFP) using the Hsieh and Klenow (2009[1]) methodology. The model suggests theoretical TFP gains of around 50%-60% for the overall economy and 10%-15% for the manufacturing sector when the United States' level of efficiency is used as a benchmark. Evidence of a deterioration in the efficiency of resource allocation over the period 2005-2015 was not found, and misallocation seems to be greater in the agricultural sector. Small and large firms face advantageous output distortions relative to medium-sized firms, and small firms tend to also face disadvantageous capital distortions. Furthermore, our results also suggest that small firms have experienced higher growth in both capital and output wedges. Finally, distortions create incentives for firms to exit the market and thwart the entrance of new participants in an industry.

Introduction

The increased availability of microdata has been accompanied by a growing economic literature analysing the role of resource allocation in explaining productivity growth. Understanding how productive factors are allocated across heterogeneous agents is vital, as distortions prevent an optimal allocation of resources and have negative consequences for aggregate productivity (Restuccia and Rogerson, 2008[2]).

Hsieh and Klenow (2009[1]) (hereafter HK) provides an empirical framework to analyse the efficiency of resource allocation that has been applied to the microdata of several countries. These results have strongly influenced the debate on the causes and effects of allocative efficiency on economic performance in recent years. Authors, such as Acemoglu and Robinson (2012[3]) and Foster et al. (2017[4]), have also argued that public policies and market imperfections are key factors that explain why some economies have low productivity growth, as the institutional framework of a country can deter the entry of new firms, innovation and the creative destruction process.

This paper provides evidence on the effect of resource misallocation on Costa Rica's aggregate total factor productivity (TFP) based on the HK model. It uses a novel firm-level database from 2005 to 2015 that comprises the universe of formal firms in the Costa

[20] The ideas expressed in this paper are of the authors and do not necessarily represent the views of the Central Bank of Costa Rica.

Rican economy. This paper not only provides additional evidence from an emerging market economy, but also extends the analysis to sectors others than manufacturing.

Costa Rica is an interesting case to study the problems stemming from the misallocation of resources. During the last 30 years, the country has implemented a set of reforms to attract foreign direct investment (FDI) and incentivise local producers to export to international markets. As a result, and as González Pandiella (2016[5]) states, Costa Rica is now characterised as a dual speed economy: an innovative, productive and export-oriented FDI sector exists alongside a low-productivity domestic sector dominated by small firms and focused on less technologically-oriented industries (e.g. agriculture, low-skilled manufacturing, tourism).

Given the novelty of the data, this paper is a first step in analysing the role that resource allocation has played in explaining the Costa Ricas productivity performance, which has been lacklustre despite an acceleration in productivity growth in recent years (see Chapter 1). This analysis will provide useful guidance to inform policies aimed at improving the efficiency of markets and achieving inclusive and sustained economic growth.

This paper deals with a set of questions related to productivity performance in Costa Rica in recent years. We measure to what extent resources are misallocated in Costa Rica and how large the TFP gains could be from eliminating distortions. Therefore, the counterfactual distribution of the size of firms in the absence of distortions can be estimated to analyse if distortions are related to firm size and the effects of distortions on firm entry and exit and productivity growth.

The document is organised as follows. In Section 2, we present the model proposed by Hsieh and Klenow (2009[1]). In Section 3 we describe the data and discuss some methodological considerations. Section 4 presents the main results and Section 5 concludes.

Model

Hsieh and Klenow (2009[1]) develop a quantitative method to measure the impact of resource misallocation on aggregate total factor productivity (TFP). This paper motivated the proposal of alternative frameworks, for instance, Bartelsman, Haltiwanger and Scarpetta (2013[6]) uses a different method to examine the role of policy-induced distortions in the allocation of resources.[21] However, we base our analysis on HK's approach because its simplicity and minimal data requirements has resulted in a body of literature using the same method, thus allowing us to compare our results with those of other countries.

Consider a representative firm that produces a final good Y in a perfectly competitive final goods market. The firm produces Y using the output Ys of S industries, with the following Cobb-Douglas production technology:

[21] Cross-country variation in the correlation between firms' size and their productivity within an industry can be explained by the presence of idiosyncratic distortions. Bartelsman, Haltiwanger and Scarpetta (2013[6]) propose a model that can be calibrated to match the observed cross-country patterns of the within-industry covariance between productivity and size in order to explain observed differences in aggregate performance.

$$\boldsymbol{Y = \prod_{s=1}^{S} Y_s^{\theta_s}, \qquad where \sum_{s=1}^{S} \theta_s = 1} \tag{4.1}$$

Each industry produces output Y_s in a monopolistic competitive market by combining M_s differentiated goods produced by a firm i with a CES technology:

$$\boldsymbol{Y_s = \left(\sum_{i=1}^{M_s} Y_{si}^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma-1}{\sigma}}} \tag{4.2}$$

where σ is the elasticity of substitution and Y_{si} is the output of the differentiated good produced by firm i in industry s. Firm i produces Y_{si} combining capital and labour, based on a Cobb-Douglas technology with constant returns to scale:[22]

$$\boldsymbol{Y_{si} = A_{si} K_{si}^{\alpha_s} L_{si}^{1-\alpha_s}} \tag{4.3}$$

Distortions can arise as a result of various factors: trade policies, credit market imperfections, labour regulations, taxes and subsidies, among others. HK introduce two types of distortions that firms could face. The first are output distortions (τ_{Ysi}), which affect the marginal product of capital and labour by the same proportion. The second are capital distortions (τ_{Ksi}) which increase the marginal product of capital relative to labour.[23]

For instance, firms that face a high output distortion are those that face government restrictions on size or high transportation costs. Such distortions would be low or negative in firms that benefit from output subsidies or other preferential treatment. Similarly, capital distortions would be high for firms that face difficulty accessing credit. HK introduce such firm-specific distortions as wedges that affect total production and capital, essentially modeled as "taxes" in the firm's profit function:

$$\boldsymbol{\pi_{si} = \max_{L_{si},K_{si}} \{(1-\tau_{Y_{si}}) P_{si} Y_{si} - w L_{si} - (1+\tau_{K_{si}}) R K_{si}\}} \tag{4.4}$$

where P_{si} is the price of output Y_{si}. From the profit maximisation problem, we can see that:

$$\boldsymbol{P_{si} = \frac{\sigma}{\sigma-1}\left(\frac{R}{\alpha_s}\right)^{\alpha_s}\left(\frac{w}{1-\alpha_s}\right)^{1-\alpha_s}\frac{(1+\tau_{K_{si}})^{\alpha_s}}{A_{si}(1-\tau_{Y_{si}})}} \tag{4.5}$$

In other words, the firm's output price is a fixed markup over its marginal costs. Note that the above equation also states that both capital and output distortions affect the firm's

22 The assumption of constant returns to scale is discussed by Gong and Hu (2016[7]). These authors claim that when this assumption fails, measuring frictions in resource allocation by the variation in revenue productivity (as is done in the HK model – see below) can over- or under-estimate the eventual TFP gains. As a result, they estimate the elasticities of capital and labour allowing decreasing or increasing returns to scale. Unfortunately, we don't have enough information to estimate both elasticities for Costa Rica, so we cannot consider the correction proposed by such authors.

23 Hsieh and Klenow (2009[1]) show in Appendix III that these two distortions are equivalent to a combination of capital (τ_{Ksi}) and labour (τ_{Lsi}) distortions.

marginal cost and, therefore, its factor allocation decisions. More precisely, the capital-labour ratio, labour allocation and output are then:

$$\frac{K_{si}}{L_{si}} = \frac{\alpha_s}{1-\alpha_s}\frac{W}{R}\frac{1}{1+\tau_{K_{si}}}$$

$$L_{si} \propto \frac{A_{si}{}^{\sigma-1}\left(1-\tau_{Y_{si}}\right)^{\sigma}}{\left(1+\tau_{K_{si}}\right)^{\alpha_s(\sigma-1)}}$$

$$Y_{si} \propto \frac{A_{si}{}^{\sigma}\left(1-\tau_{Y_{si}}\right)^{\sigma}}{\left(1+\tau_{K_{si}}\right)^{\alpha_s(\sigma)}}$$

Therefore, the allocation of resources across firms depends not only on each firm's TFP level, but also on the output and capital distortions they face. As HK discuss, to the extent that resource allocation is driven by distortions rather than firm TFP, this will result in differences in the marginal revenue products of labour and capital across firms. HK shows that, since the marginal revenue product of labour is proportional to the revenue per worker and the marginal revenue product of capital is proportional to the revenue-capital ratio, we have

$$MRPL_{si} \triangleq (1-\alpha_s)\cdot\frac{\sigma-1}{\sigma}\cdot\frac{P_{si}Y_{si}}{L_{si}} = w\frac{1}{1-\tau_{Y_{si}}}$$

$$MRPK_{si} \triangleq \alpha_s\cdot\frac{\sigma-1}{\sigma}\cdot\frac{P_{si}Y_{si}}{K_{si}} = R\frac{1+\tau_{K_{si}}}{1-\tau_{Y_{si}}}$$

$MRPK_{si}$ and $MRPL_{si}$ denote the marginal revenue products of capital, $\partial(P_{si}Y_{si})/\partial K_{si}$, and labour, $\partial(P_{si}Y_{si})/\partial L_{si}$, respectively. In other words, after-tax marginal revenue products of capital and labour are equalised across firms. This in turn implies that the before-tax marginal revenue products must be higher in firms that face disincentives and can be lower in firms that benefit from subsidies.

HK argues that firm-specific distortions can be extracted from the data using the firm's revenue productivity. Typically, as it is our case, industry price deflators are available, but firm-specific deflators are not. When industry deflators are used, differences in firm-specific prices show up in the customary measure of firm TFP, the physical productivity (TFPQ). Due to the availability of data, HK prefer to use revenue productivity (TFPR), defined as the TFPQ multiplied by the firm-specific price:

$$TFPQ_{si} \triangleq A_{si} = \frac{Y_{si}}{K_{si}^{\alpha_s}(wL_{si})^{1-\alpha_s}} \qquad \textbf{(4.6)}$$

$$TFPR_{si} \triangleq P_{si}A_{si} = \frac{P_{si}Y_{si}}{K_{si}^{\alpha_s}(wL_{si})^{1-\alpha_s}} \qquad \textbf{(4.7)}$$

Under the assumption of constant returns to scale, revenue productivity can be expressed as:

$$\mathbf{TFPR}_{si} \equiv \boldsymbol{P_{si}A_{si}} = \frac{\boldsymbol{P_{si}Y_{si}}}{\boldsymbol{K_{si}^{\alpha_s}(L_{si})^{1-\alpha_s}}}$$

$$\propto (\mathbf{MRPK}_{si})^{\alpha_s}(\mathbf{MRPL}_{si})^{1-\alpha_s}(\qquad \mathbf{(4.8)}$$

$$\propto \frac{\left(\mathbf{1}+\boldsymbol{\tau}_{K_{si}}\right)^{\alpha_s}}{\mathbf{1}-\boldsymbol{\tau}_{Y_{si}}}$$

The expression above implies that revenue productivity does not vary within an industry unless firms face capital and/or labour distortions. A high firm TFPR is, therefore, a sign that the firm has to deal with barriers that raise the firm's marginal products of capital and/or labour, rendering the firm smaller than optimal. Therefore, the dispersion of TFPR_{si} can be used to measure the distortions, and indirectly, the extent of misallocation. The TFP of each industry can be expressed as:

$$\boldsymbol{TFP_s} = \left[\sum_{i=1}^{M_s}\left(\boldsymbol{A_{si}}\frac{\overline{\boldsymbol{TFPR_s}}}{\boldsymbol{TFPR_{si}}}\right)^{\sigma-1}\right]^{\frac{1}{\sigma-1}} \qquad \mathbf{(4.9)}$$

where $\overline{TFPR_s}$ [24] is the geometric average of the marginal revenue products of labour and capital in industry *s*. Note that if marginal products were equalised across firms, TFP would be $\bar{A}_s = \left(\sum_{i=1}^{M_s} A_{si}^{\sigma-1}\right)^{\frac{1}{\sigma-1}}$.

An important conclusion from the model is that more variance in firms' revenue productivity (TFPR_{si}) decreases aggregate productivity (TFP). More precisely, fixing A_{si} and since $\sigma > 1$, from Equation 4.5 we can see that a firm with higher revenue productivity has a higher marginal cost and, hence, (proportionally) higher prices. This will induce the firm to produce less than it would in the absence of distortions. If TFPR_{si} and A_{si} are positively correlated —as the data for Costa Rica confirms and as we will discuss later —then the distortions render firms with high physical productivity (high A_{si}) to be smaller than optimal, hurting aggregate TFP (since those firms get less weight).

To be more specific, HK show that if TFPQ and TFPR are jointly log-normally distributed, there is a simple closed-form expression for aggregate TFP:

$$\mathbf{log\,TFP}_s = \frac{\mathbf{1}}{\boldsymbol{\sigma}-\mathbf{1}}\mathbf{log}\left(\sum_{i=1}^{M_s}\boldsymbol{A_{si}^{\sigma-1}}\right) - \frac{\boldsymbol{\sigma}}{\mathbf{2}}\mathbf{var}(\mathbf{log\,TFPR}_{si}) \qquad \mathbf{(4.10)}$$

In this case, the industry TFP would decline if the elasticity of substitution, σ, or TFPR dispersion increases.

When applied to the data, distortions and productivity for each firm can be inferred from:

[24] $\overline{\text{TFPR}_s} = \left[\frac{R}{\alpha_s}\sum_{i=1}^{M_s}\left(\frac{1+\tau_{K_{si}}}{1-\tau_{Y_{si}}}\right)\left(\frac{P_{si}Y_{si}}{P_sY_s}\right)\right]^{\alpha_s}\left[\frac{1}{1-\alpha_s}\sum_{i=1}^{M_s}\left(\frac{1}{1-\tau_{Y_{si}}}\right)\left(\frac{P_{si}Y_{si}}{P_sY_s}\right)\right]^{1-\alpha_s}$

$$\mathbf{1 - \tau_{Y_{si}} = \frac{\sigma}{\sigma-1} \frac{wL_{si}}{(1-\alpha_s)P_{si}Y_{si}}(} \quad \textbf{(4.11)}$$

$$\mathbf{1 + \tau_{K_{si}} = \frac{\alpha_s}{1-\alpha_s} \frac{wL_{si}}{RK_{si}}(} \quad \textbf{(4.12)}$$

$$\boldsymbol{A_{si} = \kappa_s \frac{(P_{si}Y_{si})^{\frac{\sigma}{\sigma-1}}}{K_{si}^{\alpha_s} L_{si}{}^{1-\alpha_s}}} \quad \textbf{(4.13)}$$

For Equation 4.13, the scalar $\kappa_s = w^{1-\alpha_s}(P_sY_s)^{-\frac{1}{\sigma-1}}/P_s$, is not observable. However, relative productivities—and hence reallocation gains—are unaffected by normalising κs = 1. In the data we do not observe each firm's real output Ysi, rather its nominal output *PsiYsi*. Hsieh and Klenow (2009[1]) claim that firms with high real output, however, must have a lower price to explain why buyers would demand the higher output. To get a proxy for output *Ysi* they take $P_{si}Y_{si}$ raised to $\frac{\sigma}{\sigma-1}$, which is the markup that comes from the assumed demand elasticity.

A counterfactual "efficient" output in each country is computed to compare it with the actual output levels. As previously mentioned, if marginal products were equalised across firms within an industry, TFP would be $\bar{A}_s = \left(\sum_{i=1}^{M_s} A_{si}^{\sigma-1}\right)^{\frac{1}{\sigma-1}}$. For each industry, the ratio of actual TFP (Equation 4.9) to this efficient level of TFP is estimated and then aggregated across sectors:

$$\boldsymbol{\frac{Y}{Y^*} = \prod_{s=1}^{S} \left[\sum_{i=1}^{M_s} \left(\frac{A_{si}}{\bar{A}_s} \frac{\overline{\mathbf{TFPR}_s}}{\mathbf{TFPR}_{si}} \right)^{\sigma-1} \right]^{\frac{\theta_s}{\sigma-1}}} \quad \textbf{(4.14)}$$

This exercise, however, makes no allowance for measurement error and factors omitted from the model. For instance, adjustment costs and markup variations may explain observed differences in TFPR. Therefore, efficiency gains resulting from a better allocation can be overestimated. In order to deal with that problem, we use the United States—a presumptively less distorted economy—as a benchmark.

Data

The Central Bank of Costa Rica collects firm-level information from different public entities in order to estimate macroeconomic and financial indicators. Such information was used to construct a panel database from 2005 to 2015 that provides firm-level characteristics such as output, the total wage bill, employment, the book value of capital stock, exports, imports and the industry of activity at a 5-digit level of ISIC 4. Variables are recorded in nominal terms. This database represents the universe of formal firms that operated in Costa Rica during the period of study.

Raw data consists of 209,731 firm-year observations. The database includes firms with business identification and individuals that report an income derived from a productive activity. We excluded observations with personal identification that report less or equal than 1 worker with the aim of avoiding subsistence activities.

We defined industry as the ISIC 4 identifier at the four-digit level and $P_{si}Y_{si}$ as the total sales reported by the firm. While the studies applying the HK model typically measure $P_{si}Y_{si}$ *as* the firm's value added, firms do not report information on value added and our information on sales and costs is not sufficiently robust to estimate a good proxy for value added. In particular, the main problem is the variables related to costs, because some inconsistencies are found in the raw data. We proceed by using the available data on sales, while we later estimate TFP gains using value added for the available data as a robustness exercise. Since results do not differ significantly, we chose to use reported sales as our variable of interest. As our misallocation measures are computed within each 4-digit industry, we dropped observations for industries with less than 10 firms per year.

Following Hsieh and Klenow (2009[1]), we used the wage bill instead of the number of workers to measure L_{si} to capture potential differences in human capital. The book value of the fixed capital stock was used as proxy of K_{si}. We set the rental price of capital (excluding distortions) to R = 10, considering a 5% real interest rate and a 5% depreciation rate. As HK discuss, the counterfactuals shown collapse τ_{Ksi} to its average in each industry, so the efficiency gains do not depend on R. Therefore, this parameter affects only the average capital distortion, not the estimation of the TFP gains.

Similar to HK and other Latin American countries that used the described model,[25] we set the elasticity of substitution to σ = 3. Gains from equating TFPR across industries are increasing in σ, so the use of this relatively low elasticity of substitution means that our results are conservative. In addition, we set the elasticity of output with respect to capital in each industry (α_s) as 1 minus the labour share in the corresponding industry in the United States for comparability. Even though we do not have elasticities at the industry-level for Costa Rica, adopting the U.S. shares as the benchmark is justified as the U.S. is presumed to be comparatively undistorted (both across firms and, more important, across industries). Such information was collected from the NBER, and it is the usual approach taken in the literature.

Finally, we trimmed the 1% tails of $(\mathrm{TFPR_{si}}/\overline{\mathrm{TFPR_s}}), \log(\mathrm{A_{si}M_s^{\sigma-1}/A_s})$ and re-estimate industry aggregates. Considering our requirements, we are left with around 11,000-15,000 observations per year.[26] Appendix A presents descriptive statistics for the 28,084 firms that are included in the final sample.

Results

To what extent are resources misallocated in Costa Rica?

As previously discussed, the dispersion of TFPR_{si} can be used as a measure of misallocation. Tables 4.1 and 4.2 show the ratios of 90th and 10th percentiles of TFPR and TFPQ relative to industry means. For simplicity, we present aggregate numbers as well as industry aggregations, which are described in detail in Appendix B.

First, we can observe that the dispersion differs across sectors: productivity in agricultural firms is more disperse, while the productivity of manufacturing firms is more homogeneous. In addition, these measures of dispersion are relatively stable over time.

25 See Busso, Madrigal and Pagés (2013[8]).

26 Alfaro Ureña, Manelici and Vasquez (2018[9]) impose similar restrictions for a sample of domestic firms, and find that they keep around 80% of the data for the economy. In the following section we discuss in more detail the implications of the quantity of firms that we have in our sample.

Comparing 2005 with 2015 levels, a small decline in overall dispersion is observed, with manufacturing and services experiencing the largest decline.

Table 4.1. Dispersion of TFPRsi

	2005-2006	2007-2008	2009-2012	2013-2015
All	2.49	2.50	2.38	2.40
Agriculture	3.49	3.51	3.33	3.46
Manufacturing	2.15	2.17	2.06	1.98
Commerce	2.24	2.26	2.25	2.33
Services	2.47	2.49	2.34	2.34
N	**10,464**	**11,890**	**12,919**	**13,827**

Note: Statistics are the deviation of log (TFPR) from industry means, measured as the 90th-10th percentile ratio. Industries are weighted by their production shares and N denotes the number of firms.
Source: Source: Authors' estimations.

Table 4.2. Dispersion of TFPQsi

	2005-2006	2007-2008	2009-2012	2013-2015
All	3,44	3,42	3,22	3,19
Agriculture	4,20	4,29	4,05	4,13
Manufacturing	3,11	3,05	2,95	2,81
Commerce	3,13	3,07	3,04	3,10
Services	3,45	3,48	3,20	3,13
N	**10.464**	**11.890**	**12.919**	**13.827**

Note: Statistics are the deviation of log (TFPR) from industry means, measured as the 90th-10th percentile ratio. Industries are weighted by their production shares and N denotes the number of firms.
Source: Authors' estimations.

Figure 4.1 plots the distribution of TFPR and TFPQ for 2005 and 2015, showing the information summarised in the above tables. In particular, a higher TFPQ and TFPR dispersion can be observed for Costa Rica with respect to the results obtained by HK for the United States. Hence, our results suggest that Costa Rica's economy has more distortions than the United States, as expected, but misallocation has not increased during the last decade, and has rather decreased.

Figure 4.1. Distribution of TFPR and TFPQ

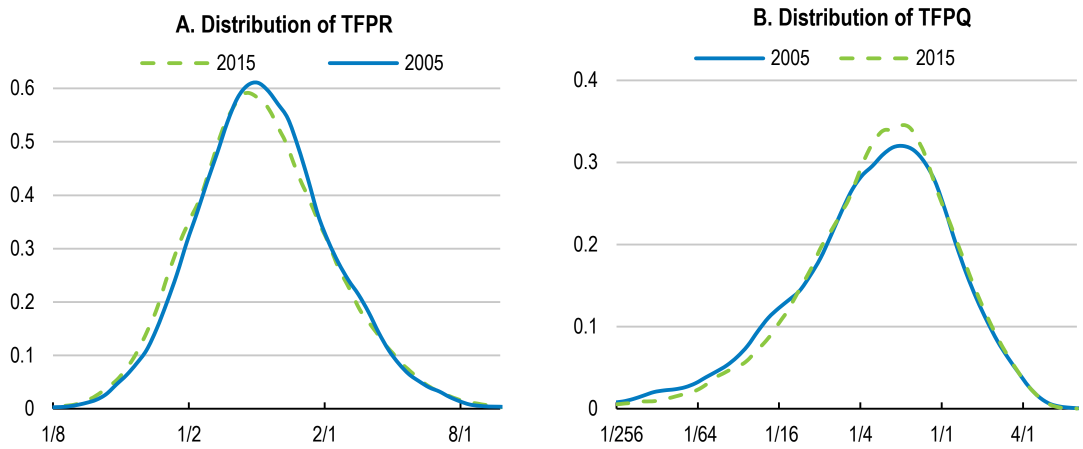


Table 4.3 puts in perspective Costa Rica's results for the manufacturing sector with other countries' TFPR dispersion. Costa Rica's manufacturing dispersion in 2005 (2.17) was similar to the Latin American region but higher than that reported for high-income economies such as the United States, Japan and France.

The role of capital and output distortions on aggregate productivity

One key question is how large productivity gains would be in the absence of distortions. Following Equation 4.4, we estimate the aggregate TFP gains from fully equalising TFPR across firms in each industry. Simultaneously, we were able to calculate the TFP boost if the allocation of resources in Costa Rica's manufacturing industry were as efficient as that observed in the United States' manufacturing sector in 1997.[27] Table 4.4 presents our results for Costa Rica, indicating that a full equalisation would improve aggregate TFP by 50%-60%. Gains from reallocation are significantly higher in agriculture, while gains in services are slightly below manufacturing and commerce. Moreover, for manufacturing industries TFP gains would be around 10%-15% if capital and labour were reallocated to equalise marginal products to the extent observed in United States in 1997, a gap that decreased during the period analysed. Finally, there is no evidence of a deterioration of the efficiency of factor allocation between 2005 and 2015, since TFP gains tend to reduce across years. On the contrary, there have been gains in efficiency in the overall economy over time, with the exception of the agriculture sector, where the gains have been minimal (Figure 4.2).

[27] In this case, U.S. information is obtained from Hsieh and Klenow (2009[1]).

Table 4.3. Dispersion of TFPRsi

Country	Period	Initial	Final
Latin America			
Venezuela	(1995-2001)	2.60	3.28
Colombia	(1982-1998)	2.50	2.90
Uruguay	(1997-2005)	2.12	2.47
Mexico	(1999-2004)	2.57	2.27
Bolivia	(1988-2001)	2.16	2.06
*Costa Rica**	*(2005-2015)*	*2.17*	*1.97*
Chile	(1996-2006)	1.57	1.77
Argentina	(1997-2002)	1.04	1.56
Ecuador	(1995-2005)	1.49	1.48
El Salvador	(2004)	n.a.	1.35
Asia			
Thailand	(2006)	n.a.	2.09
Viet Nam	(2000-2009)	n.a.	2.00
India	(1987-1994)	1.73	1.60
China	(1998-2005)	1.87	1.59
Japan	(1981-2008)	n.a.	1.40
Europe and US			
United States	(1977-1997)	1.04	1.19
France	(1998-2005)	0.92	1.00

* For comparability, all results, including for Costa Rica, are for the manufacturing sector only.

Source: Hsieh and Klenow (2009[1]) for India, China and the U.S., Hosono and Takizawa (2015[10]) for Japan, Ha and Kiyota (2015[11]) for Viet Nam, Bellone and Mallen-Pisano (2013[12]) for France, Dheera-Aumpon (2014[13]) for Thailand, Busso, Madrigal and Pagés (2013[8]) for Latin America and own estimations for Costa Rica.

Our results contrast with those presented in Dias, Richmond and Marques (2016[14]) and Benkovskis (2015[15]), where the authors find greater misallocation in the services sector. Alfaro Ureña and Vindas Quesada (2015[16]) have previously documented that the productivity of the services sector in Costa Rica –relative to the USA– is much lower in recent years. The quantitative difference in the results presented in this paper for services with respect to manufacturing is likely the result of fewer observations for the services sector with respect to the number of such firms in the economy. This is particularly true for smaller firms in the services sector, and the restrictions we impose on the micro data, especially on the size of firms. Additionally, we do not observe any information relating to the informal sector, which possibly encompasses smaller and less efficient firms. This would imply lower measured distortions, something particularly true for the services sector.[28] The data used for Portugal and Latvia presented in the aforementioned papers is less restrictive. Appendix A shows how many firms we use for our estimation given those restrictions.

[28] This is something that should be taken into consideration for the comparisons with other countries. For example, there is data for Mexico on both types of firms, and the results show that informal firms contribute significantly to overall misallocation as shown in IMF (2017[17]).

Table 4.4. TFP gains from equalising TFPR within industries and relative to 1997 U.S. gains

	Within industries			Relative to U.S. 1997		
	2005-2008	2009-2012	2013-2015	2005-2008	2009-2012	2013-2015
All	**59,6**	**56,7**	**55,6**			
Agriculture	96,5	90,9	134,8			
Manufacturing	64,6	63,5	58,1	15,2	14,4	10,6
Commerce	57,3	57,8	55,0			
Services	50,8	46,5	46,5			

Source: Authors' estimations

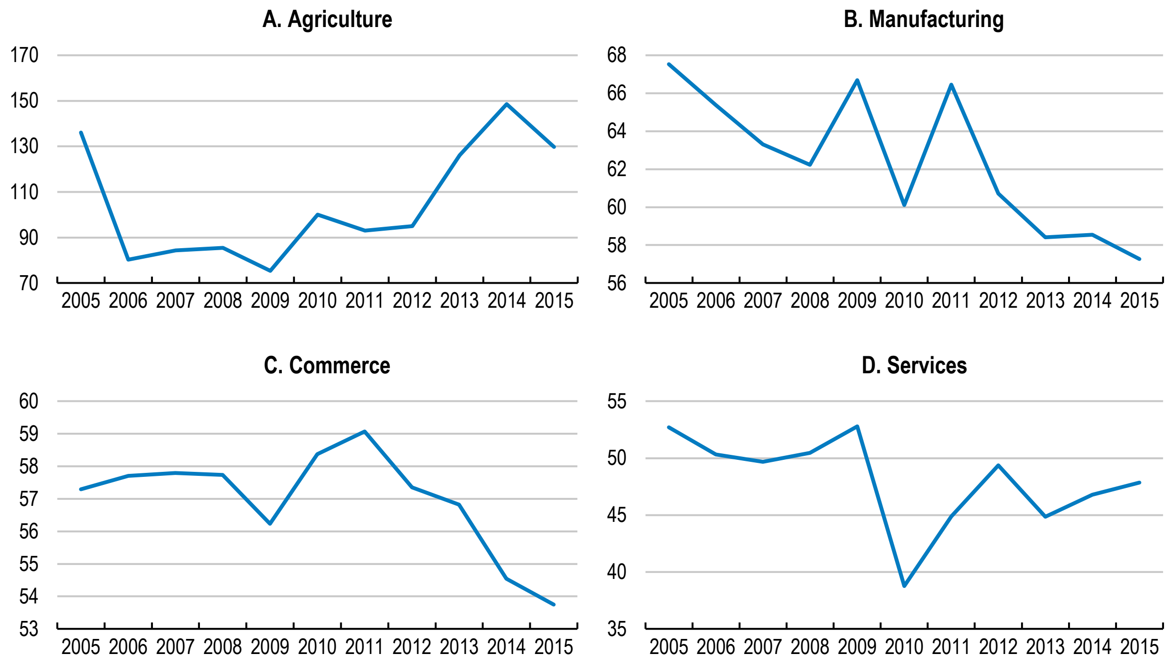
Tables 4.5 and 4.6 make a cross-country comparison of the estimated manufacturing TFP gains.

Costa Rica's reallocation gains are similar to those calculated for other Latin American countries, but greater than the gains in high-income countries.

One important feature of the model is that it constructs a measure for capital and output distortions. Taking advantage of such measures, this paper studies the relationship between these distortions and some sectoral and firm characteristics. One limitation, however, is that τ_k and τ_Y are variables that capture the effect of several distortions on the purchase price of capital and labour as production factors.

Figures 4.3 and 4.4 plot the distribution of the logarithms of capital and output wedges, suggesting that the capital distortions are more dispersed than the output ones. Furthermore, the distribution of output distortions is more symmetrical, while the distribution of capital distortions is concentrated on the positive side of the x-axis. Hence, firms face, on average, greater disadvantageous capital distortions than output ones. However, when making a comparison between 2005 and 2015, the most recent distribution of output distortions is less scattered around zero, in contrast to the distribution of capital distortions, which has increased over the same period of time.

Figure 4.2. Costa Rica: TFP gains from equalising TFPR within industries by sector



Source: Authors' estimations

Table 4.7 presents the average output distortion by main industries, suggesting important differences not only in the levels, but also in the behaviour of both wedges. First, the manufacturing and commerce sectors show a higher level of output distortions than the aggregated average. This is an expected result, since both sectors are particularly sensitive to transportation costs, regulations, market failures and weak institutions that alter the decision making process of the firm. Second, agriculture's average output distortion is very close to zero. As Equation 4.4 indicates, this implies that agricultural firms are facing advantageous output distortions in the form of subsidies that increase their prices. This is also an expected result, since Costa Rica has implemented subsidies, support policies and price controls to help these firms to survive external competition, to neutralise competitive problems and to promote exports.

Table 4.5. TFP Gains from equalising TFPR within industries

Country	Period	Initial	Final
Latin America			
Mexico	(1999-2004)	127.0	95.0
Venezuela	(1995-2001)	55.2	64.7
Bolivia	(1988-2001)	55.2	60.6
Uruguay	(1997-2005)	61.8	60.2
Argentina	(1997-2002)	52.2	60.0
Ecuador	(1995-2005)	52.7	57.6
El Salvador	(2004)	n.a.	56.7
Costa Rica*	(2005-2015)	63.8	55.7
Chile	(1996-2006)	45.0	53.8
Colombia	(1982-1998)	48.9	50.5
Asia			
Thailand	(2006)	n.a.	147.8
India	(1987-1994)	100.4	127.5
China	(1998-2005)	115.1	86.6
Japan	(1981-2008)	n.a.	39.6
Europe and US			
Spain	(1995-2007)	29.0	43.0
United States	(1977-1997)	36.1	42.9
France	(1998-2005)	30.5	30.5

* For comparability, all results, including for Costa Rica, are for the manufacturing sector only.

Table 4.6. TFP Gains from equalising TFPR relative to U.S gains

Country	Period	Initial	Final
China	(1998-2005)	50.5	30.5
Colombia	(1982-1998)	4.2	5.3
Costa Rica*	(2005-2015)	14.6	9.0
France	(1998-2005)	-4.4	-8.7
India	(1987-1994)	40.2	59.2
Japan	(1999-2004)	n.a.	6.2
Thailand	(2006)	n.a.	73.4
Uruguay	(1997-2005)	13.2	12.1
Viet Nam	(2000-2009)	n.a.	30.7

* For comparability, all results, including for Costa Rica, are for the manufacturing sector only.

Source: Hsieh and Klenow (2009[1]) for India, China and the U.S., Hosono and Takizawa (2015[10]) for Japan, Ha and Kiyota (2015[11]) for Viet Nam, Bellone and Mallen-Pisano (2013[12]) for France, Dheera-Aumpon (2014[13]) for Thailand, Busso, Madrigal and Pagés (2013[8]) for Latin America and own estimations for Costa Rica.

Table 4.7. Average output distortion by economic sector

	2005-2006	2007-2008	2009-2012	2013-2015
Aggregated	**0.53**	**0.55**	**0.53**	**0.49**
Agriculture	0.01	0.02	0.03	0.00
Manufacturing	0.66	0.68	0.65	0.61
Commerce	0.81	0.82	0.79	0.76
Services	0.42	0.46	0.42	0.38

Similarly, Table 4.8 displays the average capital distortion. A positive capital distortion may correspond to a firm that has limited access to external financing and, hence, is subject to a higher-than-average capital goods price. In this case, manufacturing firms face, on average, lower capital distortions than firms in the other sectors.

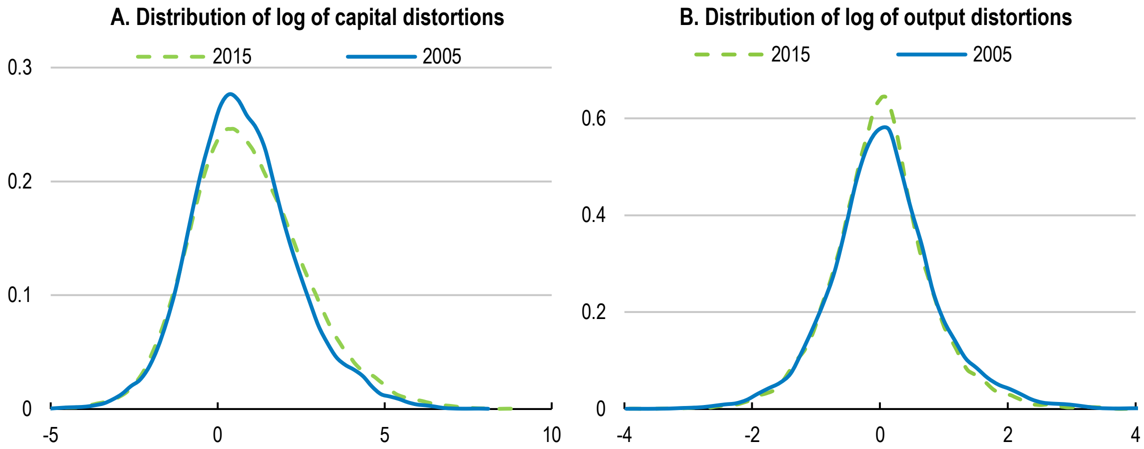
Many factors can explain this gap: manufacturing firms tend to have higher access to credit as these productive units maintain better information about their economic performance and also can use machineries and equipment as collateral in formal financial institutions. On the contrary, agricultural industries suffer from higher capital wedges. These results also show that average distortions have decreased over time, more significantly in output distortions, and especially in the agriculture sector.

Table 4.8. Average capital distortion by economic sector

	2005-2006	2007-2008	2009-2012	2013-2015
All sectors	**5.31**	**5.23**	**5.13**	**4.82**
Agriculture	6.68	6.36	5.50	4.96
Manufacturing	2.87	2.92	2.51	2.83
Services	5.28	5.49	5.93	5.49
Commerce	5.77	5.25	4.58	4.56

The following subsections will provide more detailed context into the elements that have an impact on productivity, and the dynamics of the firms given the distortions that they face.

Figure 4.3. Distribution of log of distortions



Distortions and firm size

With the notion that micro and small firms (henceforth MSEs) play a leading role in job creation and social inclusion, many countries have implemented policies to promote the entry and productivity growth of these economic agents. Costa Rica passed Law 8262 in 2002 on Small and Medium Enterprise Promotion (*Fortalecimiento de las Pequeñas y Medianas Empresas*), which gives MSEs access to technical assistance and business support programmes to increase their competitiveness and to incentivise them to export.

In this section, we explore some hypotheses about the correlation between firm size and output and capital distortions. The first hypothesis is that small firms face greater distortions, especially on capital. We created a variable on firm size following the quantitative guides in Costa Rica's Law 8262. More precisely, a parameter p is defined as a weighted average function of firms' sales assets and labour.[29] Costa Rica's Ministry of Economy, Industry and Commerce uses it to determine those firms that can access benefits that the Law for MSEs offers. We estimate this parameter for each firm and then we estimate the respective percentile based on this indicator.

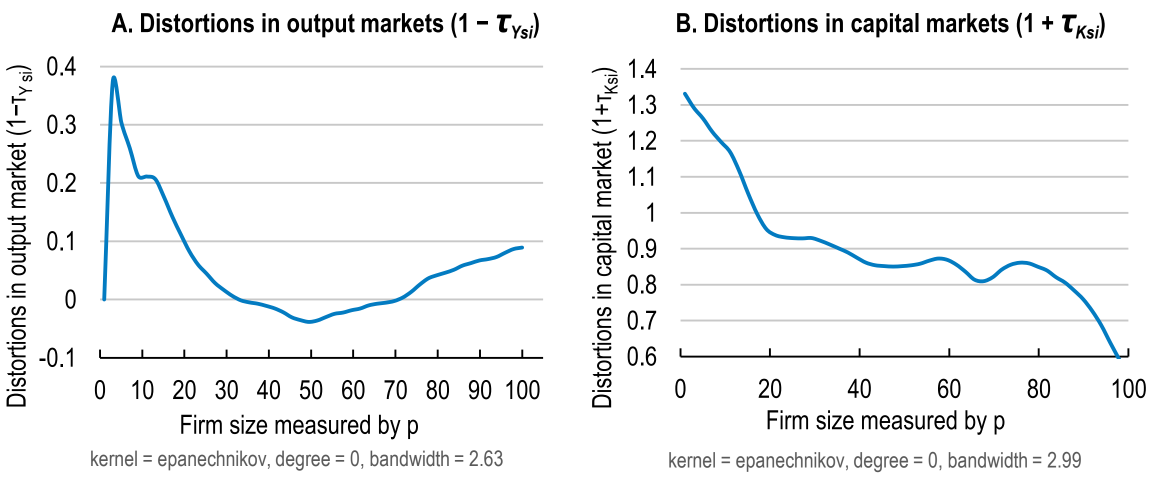
Figure 4.5 plots the relationship between the distortions in output and capital and firm size percentile. In particular, output distortions are strongly decreasing in percentiles of firm size until the 40th percentile, when the trend is reversed. As output distortions are measured as $(1 - \tau_{Y\,si})$, this result suggests that the smaller and larger firms face positive output distortions, while medium firms face low or even negative output distortions. Many factors can explain this situation. On one hand, smaller firms may be taking advantage of subsidies and programmes that the government offers to promote MSEs

[29] For example, for the year 2010, a manufacturing firm with sales of more than \$3 million, assets close to \$2 million and 100 employees would qualify as large since the parameter P would take a value of more than 100. A firm with a value of P of less than 10 qualifies as micro, above 10 but below 35 as small, and between 35 and 100 as medium sized. The weight of each variable is: 60% for the number of employees, 30% for total sales and 10% for total assets. More weight is given to the number of employees for ITC and retail/other services. Values are updated for each year.

firms while the behaviour of larger firms could be related to market power concentration, and tax subsidies to Free Trade Zone (FTZ) firms.

Similarly, Figure 4.4 plots $(1+\tau_{Ksi})$, a distortion on the price of capital. Notice that the level of distortion decreases with firm size. The correlation turns clearly negative for larger firms. As expected, smaller firms are facing higher prices for capital because of the distortions while larger firms are not. This result is in line with the asymmetries in credit access that small firms suffer.

Figure 4.4. Relationship between distortions and firm size (local polynomial smoothing)



Source: Authors' estimations

Following García-Santana et al. (2016[18]), we now turn our attention to the firm-level characteristics behind the increases in misallocation over the period. Defining the firm-specific growth rates of $\tau_{Ki,t}$ and $\tau_{Y\ i,t}$ as $\Delta ln(1+\tau_{Ki,t}) = ln(1+\tau_{Ki,t}) - ln(1+\tau_{Ki,t-1})$ (a positive value showing an increase in distortion) and $\Delta ln(1-\tau_{Y\ i,t}) = ln(1-\tau_{Y\ i,t}) - ln(1+\tau_{Y\ i,t-1})$ (a negative value showing an increase in distortion). We regress both variables on firm size, a dummy indicating exporting status (1 if the firm exports) and year and industry (ISIC 4) controls. Both regressions are corrected for potential heteroscedasticity using clustered standard errors. Table 4.9 reports the main results. First, we considered the parameter *p* as an indicator for firm size and the results suggest that there is a positive and statistically significant relationship between size and the growth of both distortions. Moreover, we included dummy variables for firm size (small, medium and large, with micro the baseline category). In this case, not only do micro firms tend to have higher growth in the two distortions, but also the gap seems to increase. Finally, the estimations show that exporting firms experience smaller changes in distortions than the others.

An important result is the direct correlation between productivity and the growth of both distortions: the most productive firms are facing faster-growing distortions. As previously discussed, when revenue productivity (that is, a proportion of both capital and output wedges) and A_{si} are correlated, then distortions reduce aggregate TFP as the most productive firms produce less than is optimal. Therefore, these results suggest that not only are the most productive firms facing disadvantageous barriers, but also the conditions they face have worsened over time.

Table 4.9. Changes in firm-level distortions, firm size and exporting status

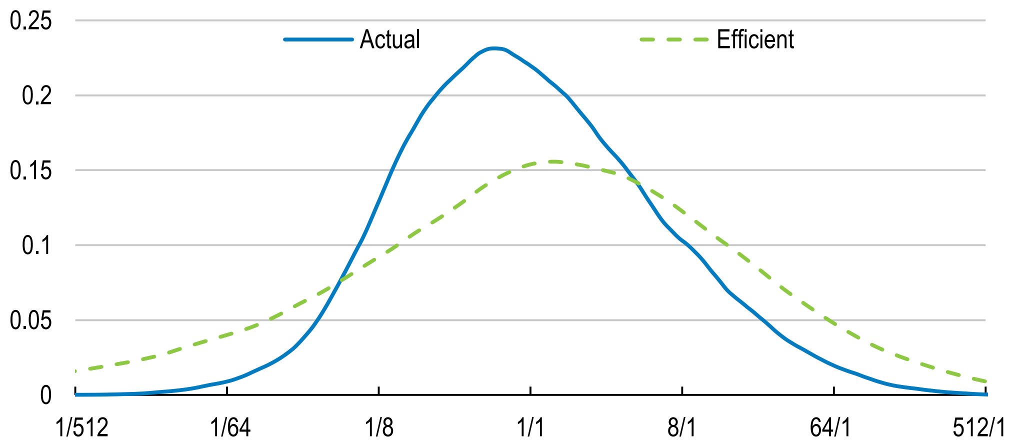
	Dep Variable: ?*ln* (1 + t_{Ksi})		Dep Variable: ?*ln* (1 - t_{Ysi})	
	(1)	(2)	(3)	(4)
Size	-0.00001***		0.00001*	
	(0.00001)		(0.00001)	
Small		-0.05442***		0.01312
		(0.01274)		(0.01031)
Medium		-0.07279***		0.07082***
		(0.01484)		(0.01392)
Large		-0.13435***		0.10672***
		(0.02037)		(0.01723)
Exporting dummy		-0.03524***		0.01779**
		(0.00920)		(0.00554)
Productivity		0.08255***		-0.08084***
		(0.00410)		(0.00756)
Industry dummies	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes
R-squared	0.02	0.02	0.05	0.05
Observations	109,807	109,807	109,807	109,807

Note: *** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

Distribution of firms in absence of distortions

A natural exercise that emerges from this model is to compare the actual firm-size distribution with the efficient scenario that would arise from equalising TFP within industries. For such purposes, we approximated the firm's size by using its output level. As Figure 4.6 shows, the hypothetical efficient distribution is more dispersed than the actual one. In particular, the model suggests that there should be fewer mid-size firms and more small and large firms if TFPR were equalised within industries.

Figure 4.5. Distribution of actual vs. efficient firm size



Source: Authors' estimations

Table 4.10 reports how the size of firms would change under an efficient scenario, in a similar fashion to HK. The entries are unweighted shares of firms. The rows are initial (actual) firm size quartiles and the columns are bins of efficient firm size relative to actual size. In particular, 0%-50% means that firms should shrink by a half or more, 50%-100% should shrink by less than a half, 100%-200% should double or triple in size and 200%+ should at least triple in size. In Costa Rica, the total share of firms that should reduce their size is approximately 56.6%, with 40.4% that should shrink by more than a half. On the contrary, around 43.5% should increase in size, with 28.2% that should at least triple in size.

Table 4.10. Actual size vs. efficient size, percentage of firms

	0%-50%	50%-100%	100%-200%	200%+	**Total**
Top size quartile	10.6	3.6	3.5	7.4	**25.0**
2nd quartile	9.8	3.8	3.6	7.8	**25.0**
3rd quartile	9.8	3.9	3.9	7.4	**25.0**
Bottom quartile	10.2	4.9	4.3	5.6	**25.0**
Total	**40.4**	**16.2**	**15.3**	**28.2**	**100.0**

Notes: The rows are the actual firm size quartiles with equal number of firms. The columns are the bins of efficient firm size relative to actual firm size. 0%-50% means that the firm size would be less than half of the actual firm size of all distortions were removed. Similarly, 200+% means that the firm size would be more than triple without distortions. The entries are the share of firms.
Source: Authors' estimations.

Firm size, exporting status and productivity

Literature suggests that under appropriate and competitive conditions, more productive firms will increase their market share at expense of the less productive firms. Labour and capital flow to the most efficient firms because these agents have the conditions and incentives to expand their production. As a result, firm size is expected to be strongly and positively correlated with firm productivity.

Furthermore, several authors such as De Loecker (2007[19]) have noted the empirical regularity that exporting firms are characterised by being more productive than nonexporters. This positive correlation between exporting status and productivity is traditionally related to the self-selection hypothesis: there are additional costs of selling goods in foreign countries, such as transportation costs, marketing, and international regulation, among others. These costs pose an entry barrier that less successful firms cannot overcome. Similarly, competition is usually fiercer in foreign markets, a feature that would again allow only the most productive firms to do well abroad.

However, the relationship between size, exporting status and productivity can become weaker if government policies favour some firms over others, allowing them to gain market share even if they are less efficient. Similarly, particular restrictions can preclude some firms from gaining market share even if they have the conditions to do so. As Busso, Madrigal and Pagés (2013[8]) discuss, the presence of distortions reduce the efficiency of resource allocation across firms, reducing aggregate output.

Table 4.11 presents the result of OLS and pooled OLS regressions of $\log(A_{si}/\bar{A}_s)$ on firm size and exporting status dummies. Micro firms are the baseline category for the size dummies. Productivity is strongly correlated with firm size. Productivity is more than twice as high in large firms. In addition, exporting firms seem to be 14% more productive than non-exporting firms. Interaction terms for firm size and exporting status were evaluated but were not significant.

The role of distortions in firm entry, exit and productivity growth

Distortions are likely to have an impact on firm dynamics within an industry. On one hand, distortions can lower a firm's profits and, thus, potentially reduce the share of new entrants and increase the probability of exit. On the other hand, entry restriction can hinder potential new entrants and give incumbents high rents. In this section, we analyse how distortions affect firm entry and exit using the baseline estimations of output and capital distortions.

Table 4.11. Regressions of log (TFPQ) on Selected Dummies

	OLS	Pooled OLS
Small	0.52***	0.45***
	(0.02)	(0.02)
Medium	1.05***	0.81***
	(0.02)	(0.03)
Large	1.67***	1.25***
	(0.02)	(0.03)
Exporting firm	0.28***	0.14***
	(0.01)	(0.01)
Year dummies	Yes	Yes
Industry dummies	Yes	Yes
R-squared	0.56	0.21
Observations	137,860	137,860

Note: *** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

Bartelsman, Haltiwanger and Scarpetta (2013[6]), calibrating a general equilibrium model of firm dynamics, find that distortions have a significant impact on endogenous selection, i.e., the entry and exit of firms. Hosono and Takizawa (2015[10]) use the following probit model to examine this relationship:

$$\boldsymbol{Prob}(\boldsymbol{Exit}_{sit} = \mathbf{1})$$
$$= \boldsymbol{\beta}_1 \overline{\mathbf{TFPRS}}_{st-1} + \boldsymbol{\beta}_2 \frac{\mathbf{TFPQ}_{sit-1}}{\mathbf{TFPQ}_{st-1}} + \boldsymbol{\beta}_3 \log\left(\mathbf{1} - \boldsymbol{\tau}_{Y_{sit-1}}\right) + \boldsymbol{\beta}_4 \log\left(\mathbf{1} + \boldsymbol{\tau}_{K_{sit-1}}\right)$$
$$+ \boldsymbol{T}_t + \boldsymbol{I}_s + \boldsymbol{\epsilon}_{sit}$$

where s denotes industry, i the firm and t the year. T_t and I_t denote year and industry dummies, respectively. The dependent variable is an exit dummy that takes one if the firm i in industry s exits in year t and zero if it survives. The first term on the right ($\overline{\mathrm{TFPRS}}_{\mathrm{st}-1}$) is average industry-level TFPR in year t. The second term $\left(\frac{\mathrm{TFPQ}_{\mathrm{sit}-1}}{\mathrm{TFPQ}_{\mathrm{st}-1}}\right)$ is the firm's TFPQ relative to the industry average. A negative coefficient is expected as more efficient firms are expected to be more competitive and have better economic performance, and therefore be less likely to exit. The third and fourth term represent both the capital and output distortions.

Table 4.12 shows the estimation results. Firstly, the marginal effect of the industry-level TFPR is not significant. However, both distortions are positively correlated to the probability of exit (here again, output distortion is measured as the logarithm of $(1 - \tau_Y)$). As a result, both output and capital distortions depress the firm's profit level and increase the probability of exit. Finally, the marginal effect of firm-level TFPQ relative to its industry average is negative and significant, which is consistent with the natural selection hypothesis. In conclusion, capital and output distortions affect not only the size distribution, but also the entry and exit of firms. The larger the output and capital distortions the firm faces, the higher the probability that the firm exits.

Table 4.12. Probit estimation of the probability of exit

	Marginal effect	Robust Std. Err.
$\mathrm{TFPRS}_{st\text{-}1}$	-0.00020	0.0012
TFPQsit-1TFPQst-1	-0.00522***	0.0007
Log(1+tK_{si})	0.00222***	0.0004
Log(1-tY_{si})	-0.00616***	0.0010
Year dummy	Yes	
Industry dummy	Yes	
Observations	119,037	
Pseudo R-squared	0.0827	

Note: *** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

Finally, we analyse the effect of distortions on firm-level physical productivity growth. Hosono and Takizawa (2015[10]) use the following regression to identify the correlation between distortions and the firm's physical productivity growth:

$$Growth_{si} = \beta_0 + \beta_1 \frac{TFPQ_{si0}}{TFPQ_{s0}} + \beta_2 \tau Y_{si0} + \beta_3 \tau K_{si0} + year_0 + I_s + \epsilon_{it}$$

Similarly to previous estimations, subscripts *s, i* and *t* respectively denote industry, firm and year. The subscript 0 denotes the year when the firms enters the market. The dependent variable is the average growth rate of firm *i*'s physical productivity. The second and third variables represent the output and capital distortions in the year of entry. The regression is corrected for potential heteroscedasticity using clustered standard errors.

The estimation results are summarised in Table 4.13, and show that the productivity level at the year of entry and the output distortion in that same year have a negative effect on the future productivity growth of firms.

Table 4.13. Estimation results of firm-level TFPQ growth rates

	Coeff.	Std. Err.
$TFPQ_{si0}/TFPQ_{s0}$	0.11763***	0.0337
t_{Ksi0}	-0.00002	0.0000
t_{Ysi0}	-0.09153***	0.0089
Year dummy	Yes	
Industry dummy	Yes	
R-squared	0.02	
Observations	2,043	

Note: *** Significant at the 1 percent level
** Significant at the 5 percent level
* Significant at the 10 percent level

Conclusion

This paper provides evidence of a negative impact of resource misallocation on Costa Rica's total factor productivity. Using the methodology proposed by HK, we estimate that Costa Rica's aggregate TFP would be 50% higher if capital and labour were allocated to equalise marginal products across firms within an industry, a hypothetical optimal scenario according to the model. For manufacturing industries, productivity gains of more than 10% could be achieved if factors were allocated to equalise marginal products to the extent observed in the United States in 1997, used as a benchmark in order to deal with the potential limitations of the model. More importantly, our estimations do not suggest an increase in factor misallocation between 2005 and 2015. On the contrary, the efficiency of resource allocation in the Costa Rican economy increased over this period.

Output distortions are less dispersed than capital wedges, suggesting a greater heterogeneity in the capital distortions that firms face. Similarly, most of the firms face disadvantageous capital distortions. Results suggest that the efficient size distribution in the absence of distortions would be more dispersed. Almost half of firms should reduce their size. Small and large firms seem to have advantageous output distortions, but small firms tend to face greater capital distortions. Small firms face, on average, large increases in capital and output distortions. On the contrary, the growth of both distortions is lower for exporting firms.

Finally, a positive relationship between productivity, firm size and exporting status was found. Distortions have a significant impact of the firm's endogenous selection by increasing the probability of exit and by limiting the share of new entrants in a particular industry. Future research can contribute to this initial analysis aimed at disentangling the distortions to shed light on the particular elements that are precluding an optimal allocation of resources.

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Annex A.

Descriptive statistics of the firms in the sample

Table A1. Firms by sector

Sector	Firms	Percentage
Agriculture	1,079	3.84
Manufacturing	2,901	10.33
Commerce	7,578	26.98
Services	15,339	54.62
Other	1,187	4.23
Total	28,084	100

Table A2. Foreign and national firms

	Firms	Percentage
National	26,477	94.28
Foreign	1,607	5.72
Total	28,084	100

Table A3. Firms by size

	Firms	Percentage
Micro	2,310	7.72
Small	18,373	65.42
Medium	4,840	17.23
Large	2,561	9.12
Total	28,084	100

Table A4. Firms by birth year

	Firms	Percentage
=2005	16,621	59.18
2006	1,791	6.38
2007	1,670	5.95
2008	1,571	5.59
2009	1,383	4.92
2010	1,229	4.38
2011	1,083	3.86
2012	1,017	3.62
2013	874	3.11
2014	615	2.19
2015	230	0.82
Total	28,084	100

Table A5. Labour by firm size (number of workers)

Size	Mean	Freq.
Micro	6.75	2,310
Small	8.09	18,373
Medium	22.48	4,840
Large	174.96	2,561
Total	25.68	28,084

Table A6. Labour by sector (number of workers)

Size	Mean	Freq.
Agriculture	70.77	1,079
Manufacturing	40.30	2,901
Services	24.47	15,339
Commerce	17.77	7,578
Other	23.35	1,415
Total	25.68	28,084

Annex F.

Industries included in the broad classifications

Table B1. Industries in Agriculture

	Description
1	Crop and animal production, hunting and related service activities

Table B2. Industries in Manufacturing

	Description
10	Manufacture of food products
11	Manufacture of beverages
13	Manufacture of textiles
14	Manufacture of wearing apparel
15	Manufacture of leather and related products
16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
17	Manufacture of paper and paper products
18	Printing and reproduction of recorded media
20	Manufacture of chemicals and chemical products
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
22	Manufacture of rubber and plastics products
23	Manufacture of other non-metallic mineral products
25	Manufacture of fabricated metal products, except machinery and equipment
26	Manufacture of computer, electronic and optical products
29	Manufacture of motor vehicles, trailers and semi-trailers
31	Manufacture of furniture
32	Other manufacturing

Table B3. Industries in Commerce

	Description
45	Wholesale and retail trade and repair of motor vehicles and motorcycles
46	Wholesale trade, except of motor vehicles and motorcycles
47	Retail trade, except of motor vehicles and motorcycles

Table B4. Industries in Services

	Description
33	Repair and installation of machinery and equipment
35	Electricity, gas, steam and air conditioning supply
36	Water collection, treatment and supply
38	Waste collection, treatment and disposal activities; materials recovery
41	Construction of buildings
42	Civil engineering
43	Specialized construction activities
49	Land transport and transport via pipelines
51	Air transport
52	Warehousing and support activities for transportation
53	Postal and courier activities
55	Accommodation
56	Food and beverage service activities
58	Publishing activities
59	Motion picture, video and television programme production, sound recording and music publishing activities
60	Programming and broadcasting activities
61	Telecommunications
62	Computer programming, consultancy and related activities
63	Information service activities
64	Financial service activities, except insurance and pension funding
65	Insurance, reinsurance and pension funding, except compulsory social security
66	Activities auxiliary to financial service and insurance activities
68	Real estate activities
69	Legal and accounting activities
70	Activities of head offices; management consultancy activities
71	Architectural and engineering activities; technical testing and analysis
72	Scientific research and development
73	Advertising and market research
74	Other professional, scientific and technical activities
75	Veterinary activities
77	Rental and leasing activities
78	Employment activities
79	Travel agency, tour operator, reservation service and related activities
80	Security and investigation activities
81	Services to buildings and landscape activities
82	Office administrative, office support and other business support activities
85	Education
86	Human health activities
87	Residential care activities
88	Social work activities without accommodation
91	Libraries, archives, museums and other cultural activities
92	Gambling and betting activities
93	Sports activities and amusement and recreation activities
94	Activities of membership organizations
95	Repair of computers and personal and household goods
96	Other personal service activities

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