Dysfunctional Firm Dynamics and Mexico's Dismal Productivity Performance

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Revised version, October 2023.

Abstract

Total Factor Productivity fell in Mexico since the early 1990s despite many reforms to increase efficiency, including multiple free trade agreements, privatization of state-owned enterprises, and the creation of regulatory agencies to promote domestic competition. We exploit a rich firm database to understand this outcome. We construct a twenty-year panel and analyze firm dynamics from two perspectives, the formal-informal and the sector composition of the economy. In the first case we show that firm dynamics were dysfunctional: high productivity formal firms exited; surviving firms hardly grew, and their productivity fell because more informalized than formalized; and entrants were less productive than survivors, mostly because of large informal entry. In the second case we show that while manufacturing performed relatively better than services and commerce, its contribution to TFP was modest because, despite a remarkable increase in manufacturing exports, its share of resources and GDP fell, and informality in the sector persisted. We document that for TFP, the formal-informal composition of the economy is more important than its sector composition. Back-of-the-envelope calculations show that absent the institutions that give rise to informality, Mexico would have experienced positive TFP growth.

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I. Introduction

Beginning in the 1990s, and following the foreign debt induced "lost decade" of the 1980s, Mexico promoted ambitious reforms to raise Total Factor Productivity (TFP) and accelerate growth.[1] Among these were issuing its first ever Competition Law and creating various regulatory agencies to increase domestic competition; privatizing more than one thousand state-owned enterprises; entering the General Agreement on Trade and Tariffs and later the World Trade Organization; and signing fourteen free trade agreements with over fifty countries including, notably, one with Canada and the United States.

As a result of these reforms, manufacturing exports almost quintupled, from 7% of GDP in 1990 to 33% in 2019. Mexico now exports more manufactures than the rest of Latin America combined. However, between 1990 and 2019 per capita GDP grew only 1% per year on average, basically because, contrary to expectations, TFP contracted at an annual rate of (-) 0.5%. Thus, a key puzzle is to understand why TFP fell despite many pro-efficiency reforms and the spectacular performance of manufacturing exports.

This paper provides a proximate explanation to this puzzle: dysfunctional firm dynamics. First, while exiting firms on the whole contributed to raise TFP, some high productivity firms exited, and some low productivity ones survived. Second, the productivity of surviving firms fell. And third, many firms with lower productivity than surviving ones entered. The net result was falling TFP.

What explains these dynamics? During the period considered, Mexico's economy was subject to two contradictory forces: on one hand, measures to improve efficiency like the ones listed above. On the other, chiefly but not only, flawed tax, labor, social insurance and contract enforcement institutions, that strongly distorted resource allocation and sustained a large informal sector (Levy, 2018).

In this paper we document that the second set of forces prevailed. After classifying firms by size and formality status, we present stylized facts on resource allocation and market shares in the aggregate and at a very detailed sector level (six-digits of the North American Industrial Classification System, NAICS). We show that firm informality became more widespread, that productivity differences between formal and informal firms increased across manufacturing, services and commerce, and that the distributions of firm productivity and firm size polarized.

Next, we construct a panel of firms and extend the Olley-Pakes productivity decomposition proposed by Melitz and Polanec (2015) to study firm dynamics from two complementary perspectives. The first one focusing on the formal-informal segmentation of the economy; the second one on the differences between manufactures, the sector most directly impacted by the

[1] Mexico's crisis erupted in 1982 when, after a period of large budget deficits and heavy foreign borrowing triggered by the discovery or large oil deposits, the world oil price collapsed, and world interest rates increased rapidly. GDP fell abruptly and growth resumed very slowly. GDP per capita did not reach its 1981 level until 1996.

trade liberalization measures, and services and commerce. These decompositions lead to the four main conclusions of our paper: first, despite the efficiency-enhancing reforms, informality persisted and was the main proximate reason behind the fall in TFP. Second, while manufacturing experienced productivity gains, these were modest because some informal firms survived, and new ones entered into the sector. Third, despite the fact that services and commerce experienced productivity losses, their share in total resources increased; manufacturing shrank even though it was the higher productivity and better performing sector. And fourth, all-in-all, misallocation increased within and across sectors.

We also study the patterns of firm growth taking advantage of our panel. Focusing on surviving firms, we document, first, that contrary to expectations, more transited from formal to informal status than in the opposite direction. Second, that very few informal firms formalized and became more productive. Third, that while the average size of surviving firms increased, their productivity fell. Finally, we show that calculations of firm growth obtained from firms' age-size profile using data from one period only, as in Hsieh and Klenow (2014), substantially overestimate firm growth. Firms in Mexico hardly grow, particularly medium and large ones.

Our paper contributes to the literature on heterogenous firms and aggregate TFP; see Restuccia and Rogerson (2008) and Hsieh and Klenow (2009). This literature is highly relevant to Latin America, a region with abnormally large dispersion in firm productivity; see IDB (2010), World Bank (2014) and CAF (2018). Previous research with cross-section data has shown that the size distribution of firms is highly biased towards smallness, that there are large differences in firm productivity even within narrowly defined sectors, and that the formal-informal segmentation of the economy plays a large role in these outcomes; see Eslava et al. (2021), Levy (2018) and Ulyssea (2018).

However, there are few studies of firm dynamics in Latin America, if only because of the paucity of panel data. An exception is Eslava et al. (2022), who construct a 30-year panel of firms for Colombia. Unfortunately, their data only cover manufacturing and exclude firms with 10 or fewer workers, leaving out most informal firms. Nevertheless, they find that the "up or out" patterns found in the United States are much weaker in Colombia as a result of the survival of small unproductive plants and much weaker selection of new ones; an important result that helps to understand why TFP underperforms in that country, and that is consistent with our findings here.

This paper exploits a large and, by Latin American standards, unique database, to study the path of TFP in Mexico. Our data covers firms of all sizes and formality status over a 20-year period in manufacturing, services, and commerce. This data permits us to construct a panel and analyze firm dynamics from the two perspectives mentioned above. To do this, we extend the dynamic Olley-Pakes productivity decomposition to a context where firms are classified by sector and formality status. Aside from providing a proximate explanation for Mexico's dismal productivity performance, our paper offers insights on the relation between sector composition, informality, and TFP, that are likely relevant to other countries also characterized by a large informal sector.

The rest of the paper proceeds as follows. Section II briefly discusses the institutions generating Mexico's formal-informal divide and their impact on resource allocation. Section III describes the data, the construction of the panel, and the criteria to classify firms. Section IV shows stylized facts on resource allocation and market shares. Section V discusses our estimates of firm productivity and carries out comparisons across firm size, sector and formality status. Section VI presents the results of the Olley-Pakes decomposition when firms are classified by formality status. Section VII focuses on surviving firms to discuss the relation between firm size, firm growth, and productivity. Section VIII presents the Olley-Pakes decomposition when firms are classified by sector. A back-of-the-envelope calculation in section IX shows that in the absence of informality Mexico would have experienced positive TFP growth. Section X presents our conclusions.

II. Brief note on informality and resource allocation

Many institutions in Mexico stand behind the fact that almost 60% of workers and 90% of firms are informal (as defined below), but three stand out (Levy, 2018). First, the legal distinction between salaried and non-salaried workers. The former are hired under a relation of dependency and subordination to work a fixed number of hours in the tasks dictated by a boss/firm, in exchange for a remuneration proportional to the time worked (salary). The latter can work on their own; or be associated with firms but without a relation of subordination, need not work a fixed number of hours, and are remunerated through various schemes: on a piece-meal basis, profit-sharing, or a commission per unit produced or sold.

Firms and workers in salaried contractual relations must jointly contribute to a fixed bundle of social insurance programs including health, pensions, housing, day care, and other benefits. In addition, firms must pay workers at least the minimum wage, cannot dismiss them at will, and when they can, incur in large severance payments.[2] On the other hand, firms and workers in non-salaried contractual relations are not subject to these regulations, and workers can access an unbundled set of health, pensions, day care, and related benefits financed from general tax revenues. The same holds for self-employed workers (one-person firms).

Because workers undervalue the benefits of IMSS, they and the firms that hire them are de facto taxed, generating incentives to evade. On the other hand, non-salaried workers are subsidized because the costs of their social insurance benefits do not have to be internalized in the contract between them and the firm, nor the contingent costs of dismissal regulations (and, of course, remunerations can be lower than the minimum wage).

Given Mexico's context of imperfect enforcement, some firms hire salaried workers without contributing to IMSS. As a result, the labor force divides into two categories: salaried workers

[2] Firms and workers contribute to IMSS (the Spanish acronym for Mexico's social security institute), to Infonavit (the housing institute) and to the Afores (the private administrators of retirement pension funds). Minimum wages are enforced by the Labor Ministry. Dismissals are regulated by labor tribunals. Henceforth we refer to all these agencies as IMSS, in the understanding that this includes Infonavit, the Afores, the Labor Ministry and labor tribunals.

hired legally (formal), and non-salaried workers together with salaried workers hired illegally (informal). Importantly, the latter can access to the same social insurance benefits that non-salaried workers receive, so that the implicit subsidy extends to them and, indirectly, the firms that hire them.

Taxation is the second institution behind the formal-informal divide. Firms pay income taxes under two regimes depending on their annual sales. If they are below approximately U$100,000, firms qualify to a preferential regime where taxes are two percent of sales (under the chapter for individuals). If sales exceed that threshold, firms are in the general regime, where taxes are 30 percent of profits (under the chapter for corporations).[3] Only firms with non-salaried workers can qualify for the preferential regime because those hiring salaried workers must register as a corporation (or cooperative). These asymmetries are accentuated by the fact that firms producing approximately 20% of the consumption basket are exempt from VAT on final sales, and firms producing an additional 26% of that basket are also exempt from VAT on intermediate inputs; and by the fact that firms in the preferential regime cannot issue VAT receipts to firms in the general regime, thus limiting their sales to final consumers or other firms in the preferential regime. The upshot is that firms with non-salaried workers and sales below the threshold, aside from having no social insurance, minimum wage or dismissal obligations, face a very low burden of income taxation and, depending on the good produced, do not have to charge VAT on their sales or pay it on their inputs.

The third institution is associated with the regulation of commercial and credit contracts. Most firms in Mexico, particularly small ones, do not register as a corporation, where the assets of the firm are separated from the assets of the owners; indeed, many are family firms in the sense that owners and workers are relatives. On one hand, registering excludes them from the preferential regime of the income tax law, and in any event the costs of doing so are high (transaction costs, notaries). On the other, the benefits, like access to commercial bank credit, may be low because when contract enforcement depends on slow and often corrupt courts, banks substantially undervalue firms' collateral, particularly if they are small.

Considered jointly, these institutions are principally responsible for three outcomes: first, firms' face different labor costs depending on the contractual status of their workers. Second, firms with non-salaried workers or hiring salaried workers illegally are de facto subsidized (as long as they are small), while firms hiring salaried workers legally are taxed. And third, the size distribution of firms is biased towards smallness. As a result, firms with very different productivities can coexist in the same (narrowly defined) market.

In other words, the institutions that give rise to the formal-informal division of economic activity de facto misallocate resources. That said, other institutions also contribute to misallocation in Mexico: the exercise of monopoly power by a few large private firms, uncompetitive and at times

[3] Levy (2018) shows that this dual tax regime generates a large discontinuity in firms' after-tax profit functions, implying that increasing sales is not profitable, unless the increase is very large.

corrupt public procurement practices by government agencies, and uncompetitive behavior by state-owned enterprises in the energy sector.

Jointly, during the last three decades the institutions that generate misallocation in Mexico operated in the opposite direction vis-à-vis the efficiency enhancing reforms promoted over the same period. In this paper we do not identify the individual impact of any of these factors on resource allocation and TFP, positive or negative. Rather, we focus on the effect of all of them at the same time, as reflected in the data captured by the Economic Census. Our paper therefore does not focus on causality, but on measuring the net impact of a large number of contradictory policies affecting the behavior of firms and workers during the period studied here.

III. Definitions and data

III.1 Definitions

We define formal firms as those that pay at least one peso in social insurance contributions to IMSS. This definition encompasses firms cheating along the extensive margin (not enrolling all of their workers with IMSS), the intensive margin (under declaring their wages), or both. It also encompasses firms mixing salaried and non-salaried workers, as long as they pay something to IMSS for their salaried workers. Further, some firms in Mexico sub-contract some or all of their salaried workers. Unfortunately, the census data does not allow to verify whether firms providing workers to sub-contracting firms in turn comply with their obligations to IMSS. Here we assume that they do, at least partly, and classify firms that sub-contract as formal. Clearly, our definition of firm formality is very generous. But it is appropriate for our purposes because it implies that the firm is registered with IMSS, is subject to labor regulations, is obligated to pay income taxes under the general regime and, when appropriate, can issue VAT receipts on its sales.[4]

There are two types of informal firms. Non-compliant ones, hiring salaried workers but not paying anything to IMSS. And legal ones, those engaged only with non-salaried workers, and thus not required to pay anything to IMSS or comply with regulations on dismissal or minimum wages.[5]

We also classify firms by size, measured by number of workers: very small, 1 to 5; small, 6 to 10; medium, 11 to 50; and large, 51 or more. The classification is attuned to Mexico's context and differs from the one used in other OECD countries, where large firms have at least 100 workers.

Firms' formality status matters for two reasons: social protection and productivity. It matters for social protection because it speaks to the social benefits that their workers are entitled to. But it

[4] Busso, Fazio, and Levy (2012) separate firms between those that comply fully and partially with their obligations towards IMSS, and those that mix salaried and non-salaried workers. They show that the productivity of these intermediate cases is similar to that of the formal firms defined here, allowing us to use a simpler classification.

[5] Thus, informality is not equivalent to illegality. In fact, as shown below, the majority of informal firms are legal. This differs from other countries, like Brazil, where firm informality implies firm illegality (Ulyssea, 2018). The fact that a large segment of informal economic activity is legal indicates that informality in Mexico is not mostly the result of imperfect enforcement; it is more complex than that and is associated with the institutions discussed in section II.

matters for productivity because it determines firms' flow and contingent costs of labor, their access to institutions in charge of contract enforcement, and sometimes their tax regime. Differently put, formality status impacts critical dimensions of firm behavior like which technologies to adopt, the number of workers to hire and their contractual modalities (including whether to comply fully or partly with the Law), the sources of finance, the range of clients, the ability to adjust to output or technology shocks, and so on.

The formal-informal labels are usually motivated by social protection considerations and can cause confusion when applied to firms. Because our focus here is on productivity, we could avoid them altogether and instead refer to two types of firms. First, those that hire salaried workers, pay IMSS, are subject to regulations on minimum wages and dismissal and the provisions of the corporate tax regime, and can issue VAT receipts to other firms. And second, those that hire salaried workers but break the Law and pay nothing to IMSS nor observe labor regulations; or have non-salaried workers, do not have to pay anything to IMSS, may pay taxes under the preferential regime but may not issue receipts for VAT, and are not bound by regulations on dismissal or minimum wages. But because this language is more cumbersome, we use the better-known formal-informal labels in the understanding that they are short-hand expressions for the very different circumstances faced by firms.

III.2 Data

Every five years, Mexico's statistical institute produces an Economic Census collecting data from firms of all sizes in urban areas operating in a fixed premise (walls, ceiling). Here we use the censuses from 1998 to 2018.[6] The Census classifies firms into sectors at the six-digit level of the NAICS. In the 2018 Census there were 981 sectors, a very detailed level of aggregation which allows to compare the productivity of firms producing very similar goods.

The number of firms captured in the Census is very large: 2.8 million in 1998, 3 million in 2003, 3.7 million in 2008, 4.2 million in 2013 and 4.7 million in 2018. Importantly, despite its broad coverage, the Census leaves out a substantial amount of economic activity. For instance, the 2018 Census only captures 52% of total employment, an indication of the large number of workers and firms carrying out their activities in mobile premises in the streets of Mexico's cities.[7] In this paper we focus on firms in manufacturing, services, and commerce, which in the 2018 Census represent 98% of all firms, 91% of employment, 66% of capital, and 629 out of the 981 six-digit sectors of the NAICS.

[6] Unfortunately, the 1993 Census cannot be used because its sector classification differs from the NAICS, which was adopted by Mexico as of the 1998 Census. In the text we refer to firms, although the Census collects data on establishments; that said, 99.7% of firms in Mexico only have one establishment (Levy, 2018).

[7] The Census captures firms in localities of 2,500 or more inhabitants, where over 80% of Mexico's population lives. It excludes firms in smaller localities and in rural areas, and firms in larger localities that do not have a fixed premise: street markets and the like. Employment in rural areas and the public sector represent less than 20% of the total, so urban employment in mobile premises is large, approximately 28% of the total. The point is that there are many more firms in Mexico than captured in the Census, although it is not possible to determine the exact number.

The Census reports the value of the capital owned by firms and the payments made for renting capital goods from other firms. To produce a homogeneous measure of capital input, we capitalize payments for rented capital (at 10%) and add them to firms' own capital. In turn, value added is corrected to incorporate payments made by firms for renting capital goods. The Census divides capital into three components: buildings and constructions, transport equipment, and machines. We have price indices for each over the 20-year period considered here and express firms' capital stock in constant prices of 2013.

We measure labor input as the value of payments to people working in the firm, including firm-owners and those hired by honorarium. This measure captures differences in remunerations associated with differences in individuals' schooling and skills. We use the consumer price index to express labor input in prices of 2013. The Census reports the number and payments to workers, but not payments to firm-owners and personnel hired under honorarium. We impute the latter using the median wage of workers in firms in the same six-digit sector.[8]

Finally, we also have price indices for value added at the three-digit level classification of the NAICS; and, in the case of manufacturing, at the four-digit level. For our TFP decompositions we assign firms into 67 three-digit sectors, 21 in manufacturing, 30 in services and 16 in commerce. Using the corresponding price indices, we compute firm value added in constant prices of 2013.

III.3 Panel of firms

Firms in the 2008, 2013 and 2018 censuses have a unique identifier generated by Mexico's statistical institute, allowing to construct a panel for this ten-year period. To extend it back to 1998, we take advantage of the fact that all censuses register firm age, name, legal status, six-digit sector, and detailed location (up to street block).

In a previous paper, we developed an algorithm to match firms in the 1998, 2003 and 2008 censuses based on these characteristics; see Busso, Fentanes, and Levy (2019). In the simplest case, if a firm in the 2003 census has the same location, legal status, name and six-digit sector than a firm in the 1998 census, and is 5 years older, we consider it to be the same firm.[9]

[8] Including firm-owners in labor input is quite important since many informal firms are family enterprises with two to three people including the owner. Workers hired under honorarium are few, but we consider them to better approximate labor input in a context where the contractual structure of firms is heavily influenced by the institutions discussed in section II. We prefer the median rather than the mean wage since the latter can be influenced by outliers. Imputations are done at the six-digit level to reflect as much as possible the specifics of each sector.

[9] The procedure works in most cases, but not all because sometimes there are minor variations in the name. For instance, a firm may appear in the 1998 Census under the name "Muebles de Madera Don Pedro" and in the 2003 one as "Muebles de Madera D. Pedro". In this case, even if the name does not match exactly, we consider it to be the same firm, as long as the other characteristics (age, location, six-digit sector) match. We thank Mexico's statistical institute for giving us access to the detailed firm records. (Muebles de madera stands for wood furniture.)

We evaluate the accuracy of our procedure comparing the results of the algorithm matches between the 2008 and 2013 census with the actual matches using the unique firm identifier given by the statistical institute. Our procedure matches exactly 96% of all firms. Missing matches refer to very small firms, as small, medium, and large ones are matched with 100% accuracy.

In sum, we construct a 20-year panel combining the exact 2008-2018 panel with the 1998-2008 almost-exact panel. We next identify firm exit, entry, and survival over the 20-year period and within each 5-year period. Because the volume of information is extremely large, in what follows we only present the results for the 20-year period and descriptive statistics for 1998 and 2018.

IV. Stylized facts: resource allocation and market shares

Table 1 shows the size and formal-informal composition of firms in 1998 and 2018. Two well-known facts are confirmed. First, the size distribution is strongly skewed towards smallness as 90% of firms have at most 5 workers and less than 1% have more than 50. Second, most firms are informal, and informality is inversely correlated with size.

Table 1: Firm size and formal-informal composition, 1998 vs. 2018

(Percentage shares)

	1998			
	Formal	**Informal and legal**	**Informal and non-compliant**	**Total**
1 – 5	9.84	66.95	13.87	**90.67**
6 – 10	3.22	0.56	0.84	**4.62**
11 -50	3.22	0.18	0.31	**3.72**
51+	0.95	0.01	0.03	**0.99**
Total	**17.23**	**67.70**	**15.07**	**100.0**
	2018			
1 – 5	5.10	62.93	21.74	**89.77**
6 – 10	2.84	0.63	2.16	**5.64**
11 -50	2.65	0.25	0.77	**3.67**
51+	0.87	0.02	0.04	**0.93**
Total	**11.45**	**63.83**	**24.71**	**100.0**

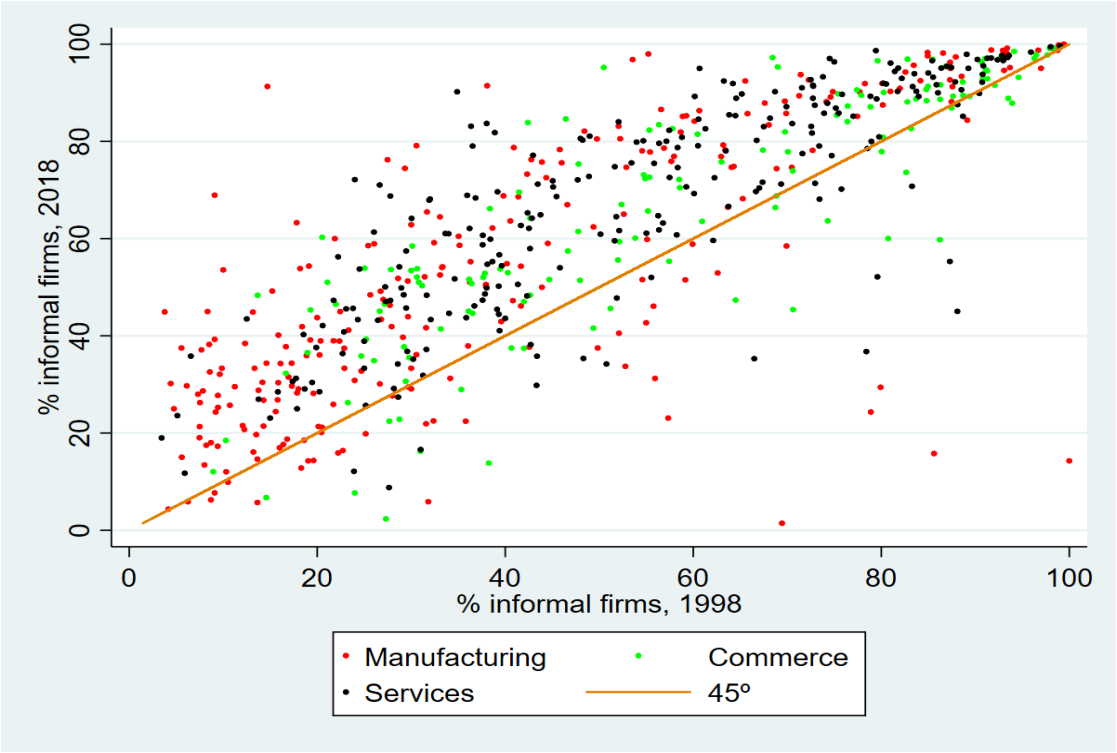
Source: authors' calculations with Census data.

Two less well-known facts are also shown in table 1: first, more than 60% of all firms are informal but legal; the majority of them very small and not registered as a corporation.[10] Second, firm informality increased between 1998 and 2018, mostly as a result of an increase in the number of informal and non-compliant firms. In 2018, one out of every four firms hired salaried workers illegally.

[10] 88% of firms in the 2018 Census were not registered as a corporation. While the census has no direct information, it is very likely that most of them are family firms, in the sense that owners and workers are relatives, a situation consistent with the absence of salaried contractual relations.

Graph 1 shows that the increase in firm informality was widespread. Each dot represents a six-digit sector, the horizontal axes measures the share of informal firms (legal or non-compliant) in the total number of firms in that sector in 1998, and the vertical one the same share in 2018. As it turns out, 524 out of the 629 dots are above the 45-degree line, indicating that in most sectors the share of informal firms increased. Further, the color of the dots shows that this occurred in 208 out of 253 sectors in manufacturing, 106 out of 136 in commerce, and 210 out of 240 in services.

Graph 1: Firm informality at the six-digit sector level



Source: authors' calculations with Census data.

Table 2 synthetizes information on employment, capital and value added; in each case, shares add to 100%. Resources moved in opposite directions between 1998 and 2018: employment in informal firms increased (all in non-compliant ones) and capital decreased, implying that formal ones became more capital intensive. There was little change in the contribution of formal and informal firms to value added, but there was substantial change in its composition within formal firms: large ones increased their share from 61 to 66% while the share of the rest fell.

To consider changes at the six-digit level, we repeat the exercise shown in graph 1 and find that the share of employment in informal firms increased in 473 out of the 629 sectors, the share of capital in 327, and the share of value added in 409. In other words, in the majority of sectors resources shifted towards informal firms.

Table 2: Resources and value added

(Shares)

	1998	2018
Employment in:		
formal firms	67.60	61.58
informal and legal firms	21.82	20.77
informal and non-compliant firms	10.58	17.65
Capital in:		
formal firms	80.43	85.62
informal and legal firms	8.73	5.85
informal and non-compliant firms	10.83	8.53
Value added in:		
formal firms	84.58	85.66
informal and legal firms	6.97	5.34
informal and non-compliant firms	8.45	9.00

Source: authors' calculations with Census data.

Table 3 provides information on market shares, with the market defined as the gross value of domestic and export sales. The aggregate market share captured by formal firms increased marginally; a result due to manufacturing, as it fell in services and commerce.[11] At the six-digit level, the market share of informal firms increased in 408 out of the 629 sectors.

Table 3: Market shares

	Formal		Informal		Total	
	1998	**2018**	**1998**	**2018**	**1998**	**2018**
Manufacturing	78.9	87.4	21.1	12.6	100.0	100.0
Commerce	74.4	70.8	25.6	29.3	100.0	100.0
Services	75.4	69.0	24.6	31.0	100.0	100.0
Total	76.3	77.5	23.7	22.5	**100.0**	**100.0**

Source: authors' calculations with Census data.

Summing up: between 1998 and 2018 there were contradictory changes in resource allocation, value added and market shares. In the aggregate, the share of informal firms increased as did the share of employment in those firms, while the share of capital fell. In parallel, the market share of informal firms in manufactures fell, increased in services and commerce, and was practically constant in the aggregate. At the six-digit level changes were also heterogenous but in most sectors informality increased as measured by the share of firms, employment, capital, market share and value added. Within formal firms, large ones became more capital-intensive and produced a larger share of value added. Within informal ones, non-compliance increased. Altogether, these results indicate that between 1998 and 2018 a small number of large formal firms absorbed a larger share of capital and generated an increasing share of value added. A

[11] The increase in the market share of formal firms in manufacturing is probably explained by the growth in exports. However, the 1998 census does not separate domestic from export sales so we cannot verify this. That said, recall that substantial economic activity is excluded from the census, mostly by informal firms in mobile premises. There is no data to measure their sales, but most likely the market share captured by informal firms exceeded 23%.

substantially larger number of small firms, mostly informal, absorbed more labor and produced a smaller share of value added.

V. Firm productivity by size, sector and formality status

V.1 Measurement of firm productivity

We follow Levinsohn and Petrin (2003) to measure firm productivity, applying the correction for functional dependence developed by Ackerberg et al. (2015). Consider the model:

$$(1) \quad VA_{ijt} = c_j + \mu_j L_{ijt} + ß_j K_{ijt} + \Omega_{ijt} + e_{ijt}$$

where VA_{ijt} stands for value added of firm i in sector j at time period t, L_{ijt} for labor, K_{ijt} for capital, Ω_{ijt} for technical efficiency observed by the firm (but not by the econometrician) and e_{ijt} is a normally distributed error term (all variables in logs). We assume that L_{ijt} is chosen in period t but K_{ijt} in t-1, and that Ω_{ijt} follows the Markov process:

$$(2) \quad \Omega_{ijt} = g(\Omega_{ijt-1}) + u_{ijt}$$

We use intermediate inputs m_{ijt} as proxy for technical efficiency Ω_{ijt}. In parallel, we assume that current intermediate inputs are a function of current technical efficiency, capital and labor, and are adjusted immediately after an efficiency shock u_{ijt} is realized, so:

$$(3) \quad m_{ijt} = m_t(\Omega_{ijt}, K_{ijt}, L_{ijt})$$

Where $m_t(\Omega_{ijt}, K_{ijt}, Lijt)$ is strictly increasing in Ω_{ijt}. Inverting the function $m_t(\Omega_{ijt}, K_{ijt}, L_{ijt})$ and denoting $\pi_t(.) = m^{-1}(.)$, equation (1) now becomes:

$$(4) \quad VA_{ijt} = c_j + \mu_{jt} L_{ijt} + ß_j K_{ijt} + \pi_t(m_{ijt}, K_{ijt}, Lijt) + v_{ijt}$$

Following Ackergberg (2015), all coefficients in (4) are estimated simultaneously.

We drop all firms with zero capital, labor, or negative value added and use the STATA code written by Rovigatti and Mollisi (2020) to estimate these regressions with data from the 1998, 2003, 2008 and 2018 censuses [12] We interpret the estimated values of $ß_j$ and μ_j as the structural parameters of each sector's production function. The estimation does not assume that $ß_j + \mu_j = 1$, so returns can vary across sectors. Because we only have price indices for value added at the three-digit level, we assume that $ß_j$ and μ_j apply to all firms in that sector (although, as mentioned, in section IX we report results for manufacturing at the four-digit level).

With the estimated values of $ß_j$ and μ_j, we compute the (log) productivity of firm i in sector j as:

[12] All coefficients are significant at the 95% confidence level; the tables with the detailed results are available from the authors.

(6) $P_{ij} = VA_{ij} - ß_j K_{ij} - \mu_j L_{ij}$

Finally, note that (6) is a revenue-based measure of productivity, reflecting the firm's technical efficiency and the price received for its output. Clearly, when there is monopoly power, (6) will overstate productivity; a situation that may happen with a few large firms in services and commerce. Despite this possible bias, (6) is our preferred measure because it allows to compare firm productivity across and not only within-sectors and does not require assumptions about the elasticity of firms' demand functions or constancy of returns to scale. In any event, to test the robustness of our measure, we also computed measures of firms' physical and revenue productivity following Hsieh and Klenow (2008), denoted TFPQ and TFPR. We find that in 1998 the correlation between (6) and TFPQ and TFPR was 0.95 and 0.86, respectively; and in 2018, 0.95 and 0.87.

V.2 Formal-informal productivity differences by size and sector

Table 4 calculates the differences in mean productivity between formal and informal firms in 1998 and 2018, separating them by sector and size. These are obtained as the coefficients of an OLS regression where formal firms are the omitted variable, and where we control by 3-digit sectors.[13]

Table 4: Average productivity gap of informal firms relative to formal ones

		By sector		
	All	**Manufacturing**	**Services**	**Commerce**
1998	(-) 1.282	(-) 1.461	(-) 1.090	(-) 1.386
s.e.	[0.0020]	[0.0048]	[0.0030]	[0.0031]
Observations	2,546,761	317,879	867,590	1,361,292
R^2	0.201	0.280	0.201	0.177
2018	(-) 1.394	(-) 1.485	(-) 1.233	(-) 1.508
s.e.	[0.0019]	[0.0057]	[0.0030]	[0.0028]
Observations	4,045,080	403,573	1,621,465	2,020,042
R^2	0.208	0.181	0.151	0.244
		By size		
	1 – 5	**6 – 10**	**11 – 50**	**51+**
1998	(-) 1.087	(-) 0.698	(-) 0.681	(-) 0.515
s.e.	[0.0024]	[0.0071]	[0.0109]	[0.0348]
Observations	2,313,982	116,286	92,151	24,342
R^2	0.137	0.233	0.215	0.395
2018	(-) 1.134	(-) 0.586	(-) 0.591	(-) 0.254
s.e.	[0.0027]	[0.0046]	[0.0068]	[0.0219]
Observations	3,600,639	245,315	157,920	41,206
R^2	0.126	0.370	0.274	0.415

Source: authors' calculations with Census data.

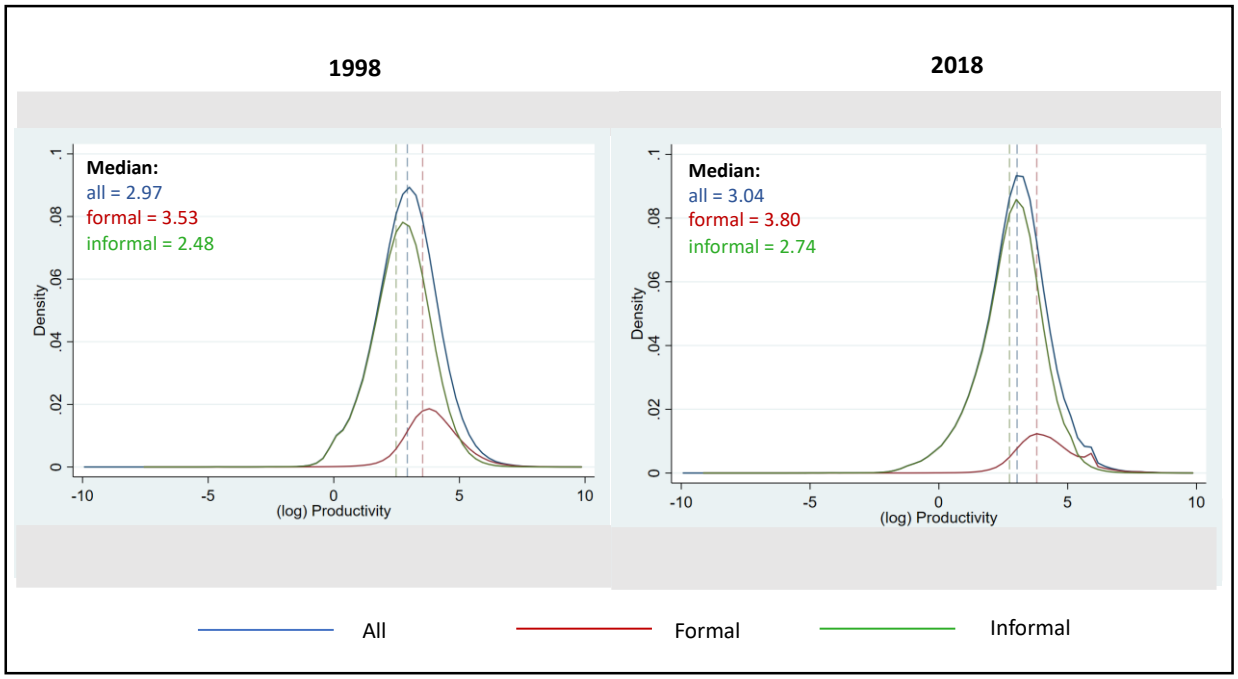
[13] The coefficients result from the OLS regression $P_i = \alpha + \beta D_i + \gamma_s + \varepsilon_i$, where $D_i = 1$ is informal and $D_i = 0$ otherwise and γ_s are controls for 3-digit sectors. The regression is equivalent to a mean test of productivity differences between formal and informal firms. All coefficients are statistically significant at the 95% confidence level.

The message from table 4 is clear: regardless of how firms are classified, on average formal ones are more productive. Note that differences diminish with size and that, considering all firms, the difference in average productivity increased from 28% in 1998 to 39% in 2018.

V.3 Productivity distributions

Graph 2 presents the distribution of P_i in 1998 and 2018.[14] In both years, the median of the formal distribution is higher than the informal. The median of the complete distributions in 2018 is 7% higher than in 1998.

Graph 2: Formal-informal firm productivity distributions



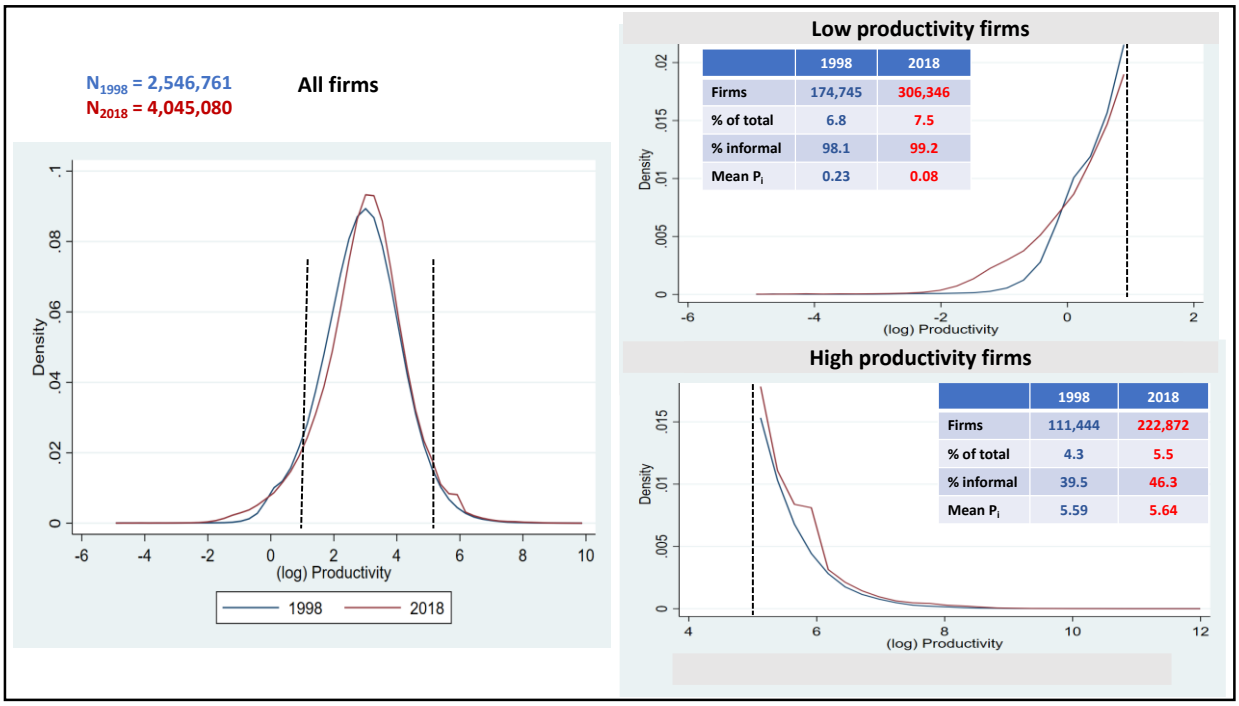
Source: authors' calculations with Census data.

While the median and the mean of the formal productivity distributions in both years are higher than those of the informal distributions, there is considerable overlap between them. This implies that some informal firms have higher productivity than some formal ones; in fact, as we show below, some informal firms are very productive. The point here is that Mexico's informal sector is very heterogeneous, and that some firms may be informal not to avoid the Law, but because they consider that non-salaried contracts with their workers are the best fit for their business model.

[14] These are the distributions of P_i of firms in all sectors. Levy (2018) constructs similar distributions for 1998 and 2013 from the envelope of the 6-digit sector distributions of $TFPR_i$. The moments of those distributions are very similar to the ones in graph 2. The result that the formal and informal productivity distributions overlap, but that the mean and median of the formal distribution is to the right of the informal one is robust, as is the result that overtime measures of dispersion increased (see below).

The left panel of graph 3 overlaps the 1998 and 2018 distributions and the right panels magnify the tails, below log one productivity and above log five. Between 1998 and 2018 the mean increased from 2.90 to 2.96 (or 6%), the standard deviation from 1.25 to 1.34, and the difference between firms in the 90th/10th percentiles from 3.14 to 3.26. Clearly, the productivity distribution polarized.

Graph 3: 1998 and 2018 productivity distributions with amplified tails



Source: authors' calculations with Census data.

The right panels show that polarization resulted from a fattening of both tails, as the share of firms in each increased. Note that while the left-tail is almost wholly populated by informal firms, the right one is populated by a mix of both, and in fact in 2018 almost half of Mexico's high productivity firms were informal. Note that mean productivity fell in the left tail while it increased in the right one, again highlighting the polarization of the productivity distribution.

Graph 3 provides an initial insight to understand why TFP fell in Mexico between 1998 and 2018. On one hand, the number of high productivity firms doubled. A few of these survived since 1998 but, as we show below, the majority were new entrants. Regardless, these were the expected results from the measures to improve resource allocation. On the other, despite these measures, the number and share of low productivity firms also increased, and their average productivity fell. The balance yields a 6% increase in the mean between 2018 and 1998 and implies an annual growth rate of the simple average firm productivity of 0.3%; quite unimpressive, but at least positive. However, this result ignores changes in resource allocation among firms and, unfortunately, when this is considered as we do in the next sections, it is reversed.

VI. Dynamic Olley-Pakes TFP decomposition: formal versus informal firms

VI.1 Formulas

We begin writing the expression for TFP subject to analysis. Let:

(7) $r_{ij} = K_{ij}^{ßj} * L_{ij}^{\mu j}$

(8) $R = \sum_i \sum_j r_{ij}$

(9) $v_i = r_i/R \quad ; \qquad \sum_i v_i = 1$

so that r_{ij} are the resources captured by firm i in sector j, R is total resources, and v_i is the resource share corresponding to the ith firm. TFP is the weighted average of firm productivity P_i, where the weights are the share of resources captured by each, v_i:

(10) $TFP = \sum_i v_i * P_i$

Expression (10) serves to make two points: first, TFP depends on the joint distribution of P_i and v_i. Second, it is additively decomposable, so one can compute TFP adding subsets of firms with their respective factor shares classified with different criteria.

Melitz and Polanec (2015), henceforth M-P, develop a methodology, labelled the dynamic Olley-Pakes productivity decomposition, to identify the contribution of firm exit, survival, and entry to the change in TFP between two periods, denoted here 1 and 2 (rather than 1998 and 2018, to simplify notation). Let X, S and E denote the set of exiting, surviving, and entering firms. Further, let n_1 (= $n_S + n_X$) and n_2 (= $n_S + n_E$) be the number of firms in the first and second period. TFP in each period is then:

(11) $TFP_1 = v_{S1} * P_{S1} + v_X * P_X$

(12) $TFP_2 = v_{S2} * P_{S2} + v_E * P_E$

where $v_{S1} = \sum_{nS} v_{i1}$ is the share of resources captured by surviving firms in period 1, $P_{S1} = \sum_{nS}(v_{i1}/v_{S1}) * P_{i1}$ their weighted productivity, $v_X = \sum_{nX} v_i$ the share of resources in exiting firms, $P_X = \sum_{nX}(v_i/v_X) * P_i$ their weighted productivity, and $v_{S1} + v_X = 1$. Similar expressions apply for period 2, except that entering firms replace exiting firms, and $v_{S2} + v_E = 1$.

M-P show that:

(13) $\Delta TFP = TFP_2 - TFP_1 = v_X(P_{S1} - P_X) + (PS_2 - PS_1) + v_E(P_E - P_{S2})$

This is a very intuitive expression. The first term in the RHS measures the contribution of exiting firms to ΔTFP. It is positive if they are less productive than surviving firms in the first period, with the magnitude of the effect depending on the share of resources released by exiting firms, v_X. The

second term captures the contribution of surviving firms and is positive if their weighted productivity increases. The last term measures the contribution of entering firms: they increase TFP if they are on average more productive than surviving ones in the second period, with the magnitude of the effect depending on the share of resources captured by them, v_E.

Expression (13) has a standard Schumpeterian interpretation: TFP increases if low productivity firms (relative to those that survive) die, if those that survive improve their performance, and if the ones that enter are more productive than the ones that survived. If all three conditions hold, there is Schumpeterian "creative destruction", and TFP unambiguously increases. If some do not, the net effect depends on the magnitude of each.

Expression (13) can be extended to separate between formal and informal entering and exiting firms, with F and I denoting each (where, quite naturally, $v_{XF} + v_{XI} + v_{S1} = 1$ and $v_{EF} + v_{EI} + v_{S2} = 1$):

$$(14) \quad \Delta TFP = [v_{XF}(P_{S1} - P_{XF}) + v_{XI}(P_{S1} - P_{XI})] + (P_{S2} - P_{S1}) + [v_{EF}(P_{EF} - P_{S2}) + v_{EI}(P_{EI} - P_{S2})]$$

To separate the term for surviving firms between formal and informal ones, note that firms can change status between periods: formal ones may remain formal (denoted here FF) or may turn informal (denoted FI); and similarly, informal firms may formalize, IF, or may remain in formal, II. Note as well that $v_{FF1} + v_{FI1} + v_{IF1} + v_{II1} = v_{S1}$ and similarly for period 2. Letting factor shares within surviving firms be $b_{FF1} = v_{FF1}/v_{S1}$ and so on (so that $b_{FF1} + b_{FI1} + b_{IF1} + b_{II1} = 1$ and similarly for period 2), we have:

$$(15) \quad (P_{S2} - P_{S1}) = (b_{FF2}P_{SFF2} - b_{FF1}P_{SFF1}) + (b_{FI2}P_{SFI2} - b_{FI1}P_{SFI1})$$
$$+ (b_{IF2}P_{SIF2} - b_{IF1}P_{SIF1}) + (b_{II2}P_{SII2} - b_{II1}P_{SII1})$$

where the P's on the RHS of (15) are the weighted average of the productivity of each type of surviving firm in each period, where the weights are the factor shares captured by each. Substituting (15) in (14) we obtain the formula used in our calculations.

VI.2 Panel of firms, firm productivity, and factor shares

Table 5 displays firm exit, survival, and entry between 1998 and 2018. Consider the first row. There were 439,521 formal firms in 1998, of which 343,389 exited before 2018. Of the remaining 96,132 firms that were formal in 1998 and survived to 2018, 58,280 continued as formal and 37,852 changed their status to informal. In parallel, 424,208 formal firms entered. Considering these, plus the formal ones that survived as formal, together with the 19,539 informal firms that survived but formalized (from the second row), yields a total of 502,027 formal firms in 2018. The second row is read similarly.

We highlight two facts in table 5: first, 82% of the firms present in the market in 1998 exited before 2018, and 88% of those present in 2018 entered after 1998. Differently put, there was a lot of firm churning. That said, these figures underestimate churning because firms that entered after 1998 but exited before 2018 are not considered. In fact, using the data from the 2003, 2008

and 2013 censuses, it turns out that between 1998 and 2018 5.4 million firms exited and 6.9 million entered (an average of 285,000 and 364,000 per year, respectively). But even these figures underestimate churning because firms that enter and exit between two contiguous censuses are excluded (say, one that entered in 2005 but exited in 2007), and because the census only captures firms in urban areas in fixed premises. The point here is that firm churning in Mexico is substantially larger than what table 5 suggests.

Table 5: Firm dynamics by formality status

	Starts 1998	Exit	Survival		Entry	Ends 2018
			survive	change type		
Formal	439,521	343,389	96,132	stay formal 58,280 Δ to informal 37,852	424,208	502,027
Informal	2,107,240	1,737,305	369,935	Δ to formal 19,539 stay informal 350,396	3,154,805	3,543,053
Total	**2,546,761**	**2,080,694**	**466,067**	**466,067**	**3,579,013**	**4,045,080**

Source: authors' calculations with Census data.

The second fact is that among surviving firms, 12% changed status, the majority towards informal. Among those that were formal, 39% survived and informalized, while among those that were informal, only 5% formalized. For every firm that changed from informal to formal status, almost two changed in the opposite direction. Differently put, the idea that informal firms that survive formalize is not supported in the Mexican data, even over a 20-year period.

VI.3 Results

Table 6 shows factor shares and the weighted productivity of formal and informal exiting, surviving and entering firms. Substituting these values in equations (14) and (15) we obtain a key result: between 1998 and 2018 TFP fell by 7.4%, implying an annual growth rate of (-) 0.3%.[15]

What explains this dismal performance? Begin with exit. Since $v_{XF}(P_{S1} - P_{XF}) = 0.095$, the exit of formal firms contributed to increase TFP; and since $v_{XI}(P_{S1} - P_{XI}) = 0.262$, so did the exit of informal

[15] As a check on our results, we computed the change in aggregate TFP calculating the Solow residual from an aggregate production function using national accounts data. Setting the index of TFP at 1.00 in 1998, its value in 2018 was 0.899 (a fall of 9.1%). This can be contrasted with our findings using the O-P decomposition where, again setting the index of TFP at 1.00 in 1998, results in a value of 0.936 in 2018 (a fall of 7.4%). These results are very close. The slightly larger fall in the first case is probably due to the fact that the whole economy is more informal than the segment captured in the Census.

ones, in fact, significantly more. Altogether, exit by itself would have contributed to raise TFP by 35.7%, clearly a good outcome. That said, note that some exiting formal firms had higher productivity than some surviving informal ones (i.e., $P_{XF} > P_{SI}$, and by a large margin). If those exiting formal firms had survived, and those informal surviving ones exited, the exit process could have made a larger contribution to raise TFP. So, while exit helped, it was still problematic because relatively productive firms exited.

Table 6: Factor shares, firm productivity by formality status and ΔTFP

	Factor Shares		Weighted Firm Productivity		Contribution to
	1998	**2018**	**1998**	**2018**	**ΔTFP**
Formal	$v_{XF} = 0.510$		$P_{XF} = 4.449$		0.095
Exit Informal	$v_{XI} = 0.160$		$P_{XI} = 2.998$		0.262
All	$v_X = 0.671$		$P_X = 4.103$		0.357
FF	$v_{SFF1} = 0.270$	$v_{SFF2} = 0.172$	$P_{SFF1} = 4.837$	$P_{SFF2} = 4.786$	0.027
FI	$v_{SFI1} = 0.024$	$v_{SFI2} = 0.011$	$P_{SFI1} = 4.379$	$P_{SFI2} = 4.204$	(-) 0.097
Survival IF	$v_{SIF1} = 0.008$	$v_{SIF2} = 0.007$	$P_{SIF1} = 4.269$	$P_{SIF2} = 4.304$	0.038
II	$v_{SII1} = 0.026$	$v_{SII2} = 0.016$	$P_{SII1} = 2.913$	$P_{SII2} = 2.876$	(-) 0.012
All	$v_{S1} = 0.328$	$v_{S2} = 0.206$	$P_{S1} = 4.634$	$P_{S2} = 4.590$	(-) 0.044
Formal		$v_{EF} = 0.570$		$P_{EF} = 4.496$	(-) 0.054
Entry Informal		$v_{EI} = 0.223$		$P_{EI} = 3.096$	(-) 0.333
All		$v_E = 0.793$		$P_E = 4.102$	(-) 0.387
Total	1.000	1.000	4.273	4.199	(-) 0.074

Source: authors' calculations with Census data. The last column lists the terms in the RHS of equations (14) and (15).

Survival is more problematic. Its contribution to TFP was negative because the weighted productivity of survivors fell ($P_{S2} < P_{S1}$). This fall reflects asymmetric behavior across the four firm statuses and is discussed in more detail in the next section but, all in all, surviving firms reduced TFP by 4.4%.

Entry is the most problematic. While formal entrants were more productive than informal ones ($P_{EF} > P_{EI}$) and attracted more resources ($v_{EF} > v_{EI}$), they were less productive than survivors ($P_{EF} < P_{S2}$); as a result, their contribution to ΔTFP was negative, (-) 5.4%. The same occurred with informal entrants, and by a much larger margin, (-) 33.3%. If the resources channeled to entrants had instead been allocated to survivors, TFP would have increased. In other words, it would have been better if new investments and new hirings had been allocated to expand existing firms rather than to create new ones, particularly informal ones, and the fact that this did not happen speaks volumes to the obstacles that Mexican firms face to grow.[16]

[16] Consider three examples, each linked to the institutions discussed in section II. First, if a firm grows it may need to change its contractual structure from non-salaried to salaried (for instance, to coordinate tasks among a larger set of workers). This, however, would increase substantially its flow and contingent costs of labor. Second, if firm growth implies crossing the threshold established in the tax code to qualify for the preferential regime, its after-tax profits can fall. And third, to issue bonds or attract new shareholders to increase its capital, the firm needs to be registered as a corporation and investors need to trust that their rights will be respected, a dubious proposition in a context of imperfect contract enforcement, particularly when it comes to small firms. That said, there may be other factors affecting firm growth, particularly of medium and large ones, like uncertain access to energy or costly finance.

Very poor selection of entrants was the single most important factor behind the fall in TFP, reducing it by 38.7%, substantially larger than the negative contribution of survival (as noted, 4.4%). Selection at entry matters a lot because, as table 5 shows, the vast majority of firms in 2018 entered after 1998 and because, as table 6 shows, by 2018 surviving firms only captured 20.6% of all resources (v_{S2}) while entrants captured 79.3% (v_E). In other words, over the medium term, 20-years in this case, entry is key for TFP, and the fact that a lot of informal firms entered with lower productivity than survivors punished TFP considerably. Very poor selection at entry explains the fattening of the left-tail of the productivity distribution between 1998 and 2018 shown in graph 3.

Further, note that even though informal entrants captured less than half of the resources than formal entrants did ($v_{EI} < 0.5*v_{EF}$), they captured more than all survivors ($v_{EI} > v_{S2}$). Moreover, their productivity was almost one-third lower than that of formal entrants ($P_{EI} \approx 0.68P_{EF}$). In other words, informal entry mattered a lot. There is a lesson here: because most informal firms are very small, and each one captures a practically insignificant share of the economy's resources, they are usually thought of as a second-order issue, at least from the point of view of TFP. But this thinking is flawed because when added up these firms absorb a lot of resources (22% in 2018!), and because their productivity is very low, pulling the economy-wide average down.

The last column in table 6 also allows to identify the contribution of formal and informal firms to the change in TFP. Altogether, the exit, entry and survival of formal firms, including those that formalized, increased TFP by 10.6%. In parallel, the exit, entry and survival of informal firms, including those that informalized, reduced TFP by 18%. Netting them out results in the 7.4% fall already noted. Clearly, the persistence of informal firms during this time period was extremely damaging to TFP in Mexico.

One more result. The capital stock of the firms considered in tables 5 and 6 increased by 100% between 1998 and 2018 and the labor force by 85%. In other words, aggregate K/L increased. Nonetheless, TFP fell. Thus, contrary to what is at times stated, higher capital intensity does not always translate into more productivity. In Mexico's case, the increase in aggregate capital intensity hides considerable differences between formal and informal firms. Surviving formal firms became more capital intensive while surviving informal ones less; and entering formal firms were three times more capital intensive than entering informal ones. In other words, the formal sector became more capital intensive and the informal one less, but the weight of the latter dominated from the perspective of TFP.

VII. Firm size, firm growth, and productivity

VII.1 Firm growth and productivity

A significant advantage of our twenty-year panel is that, by focusing on survivors, we can observe the same firm in two time periods time and study the relation between firm growth and productivity. Table 7 provides the relevant data. Altogether, surviving firms grew 16.5%, from 8 to 9.3 workers over the 20-year period considered here, but their productivity fell by 4.4%. This result highlights the disconnect between changes in firm size and changes in productivity that

occurs in a context of large misallocation and is the product of different behavior depending on firms' transitions.

Firms that remained formal (FF) grew 20%, from 45.8 to 55.1 workers but their productivity fell, although by 5.1% over 20 years. Despite the fall in their productivity, these firms made a positive contribution to ΔTFP, as can be seen in the last column of table 6. The reason is that, within the set of surviving firms, they were the highest productivity ones and they attracted resources from other firms with lower productivity ($b_{SFF2} > b_{SFF1}$). In this case, resource reallocation within survivors compensated the disappointing productivity performance of firms that survived as formal.

On the other hand, firms that informalized (FI) shrunk and their productivity fell by 17.5%; clearly, it would have been better if they had died. Firms that formalized (IF) increased their size considerably, by 39%, and their productivity, although again by a small amount, 3.5% over 20 years. Finally, those that stayed informal (II) grew 5% but their productivity fell by 3.7%; again, it would have been better if they had died.

Table 7: Average firm size and (log) productivity of surviving firms

		Average Size			Weighted (Log) Productivity		
	Number	**1998**	**2018**	**% change**	**1998**	**2018**	**% change**
FF	58, 280	45.8	55.1	20.3	4.837	4.786	(-) 5.1
FI	37,852	7.6	6.1	(-) 19.8	4.379	4.204	(-) 17.5
IF	19,539	6.7	9.3	38.8	4.269	4.304	3.5
II	350,396	1.8	1.9	5.5	2.913	2.876	(-) 3.7
All	**466,067**	**8.0**	**9.3**	**16.2**	**4.634**	**4.590**	**(-) 4.4**

Source: authors' calculations with Census data.

Table 7 allows two observations. First, informality was a status that allowed firms that should have exited to survive. Even though firms that survived as informal attracted very few resources, their productivity was so low that they more than offset the modest contribution to ΔTFP from firms that survived as formal or formalized. And second, it is often stated that "informal firms that survive formalize, grow, and become more productive". Unfortunately, in the case of Mexico this statement applies only to 19,539 out of the 369,935 firms that were informal in 1998 and survived to 2018; the remaining 95% did not formalize or become more productive.

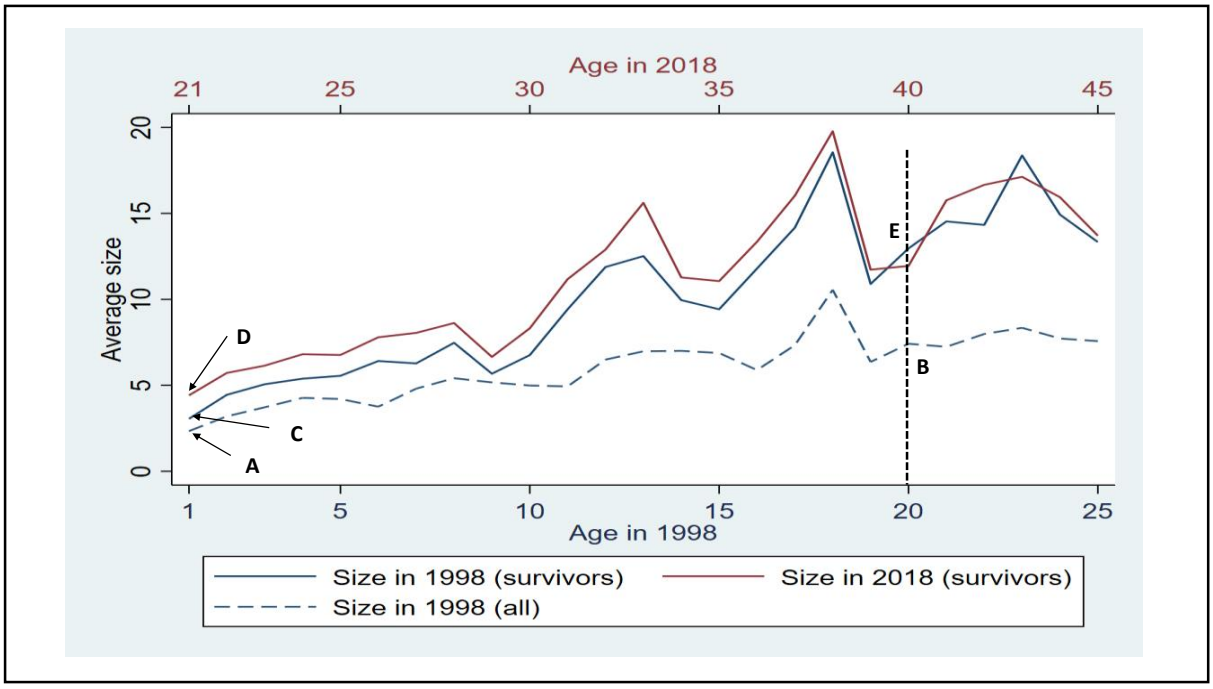
VII.2 Age-size profiles and firm growth

Graph 4 shows the relation between the size and age of surviving firms in 1998 (blue line) and in 2018 (red line), and of all firms in 1998 (dotted blue line). The lower horizontal axes depicts their age in 1998 and the upper one in 2018.

Studies that infer firm growth from their age-size profile with data from only one year, as in Hsieh and Klenow (2014), focus on the dotted line and use data from all firms in that year. In this case, one year old firms in 1998 were at point A and had on average 2.34 workers and, 20 years later, were at point B, with an average of 7.55 workers (point B), implying that they grew by 322%.

However, not all firms at point A survived 20 years and reached point B; in fact, most did not. To measure firm growth properly, we need panel data from two periods and focus on the same firms, that is, firms that survive two decades, as captured by the solid blue and red lines. Critically, firm growth is the vertical movement between the blue and red lines, not the horizontal movement along the blue line (point E). Point C represents one-year old firms in 1998, meaning they entered in 1997; on average, they had 3.05 workers. In 2018 they were 21 years old and were at point D with, on average, 4.42 workers. Thus, firms grew by 26.3%, far from the 322% implied by the dotted line.

Graph 4: Firms' age-size profiles



Source: author's calculations with Census data.

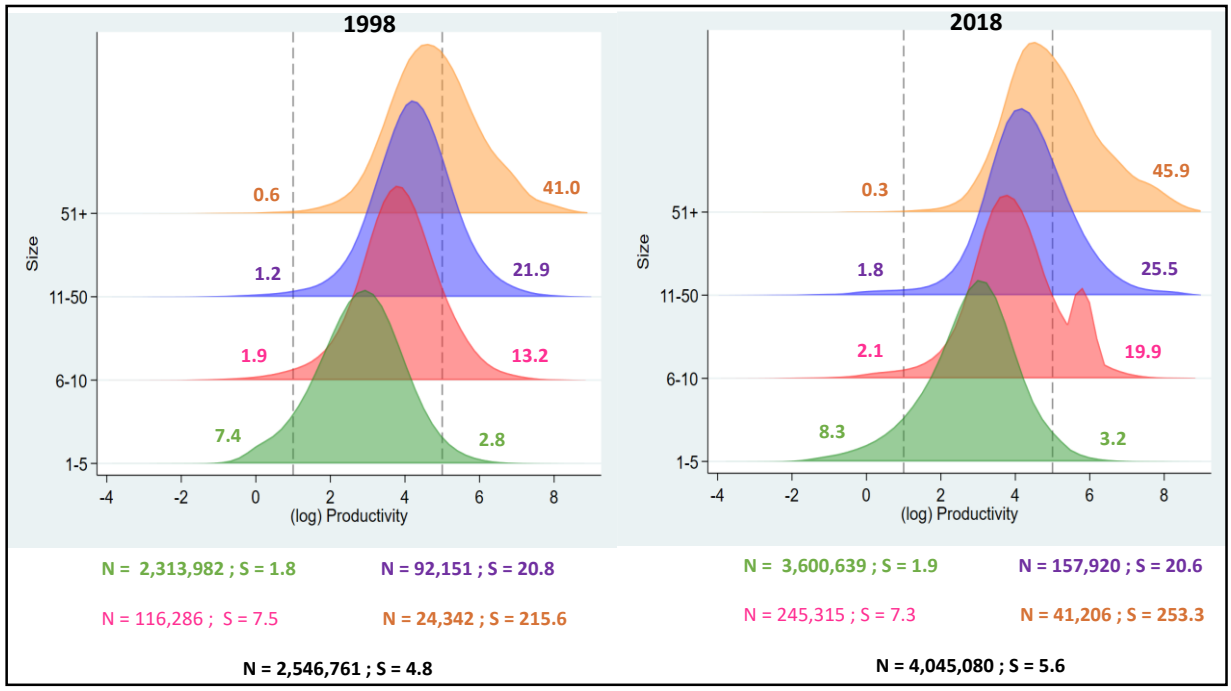
Because the vertical distance between the blue and red lines is fairly constant, firm growth is decreasing in size. Firms with approximately 5 workers in 1998 had 6.1 in 2018, so they grew 22%; firms with approximately 12 workers in 1998 had 13 in 2018, so they grew 8.3%; and so on. Importantly, firms with 15 or more workers in 1998 only grew 5%; an almost insignificant amount considering that this occurred over two decades (an annual growth rate of 0.2%, less than one tenth the average growth rate of GDP in that period!). The point here is that average firm growth was caused mostly by very small and small firms, whose growth in percentage terms is inevitable large, as they pass from 2 to 3 or 3 to 4 workers; medium and large ones hardly grew.

VII.3 Changes in average firm size and changes in productivity

Graph 5 depicts the same productivity distributions for 1998 and 2018 presented in graph 3 but segmented by ranges of size. For each size range, we show the share of firms in each tail, and below the graph, the number of firms in each range, N, their average size, S, with totals in black.

Various observations are relevant. First, recall from table 5 that almost nine out of ten firms present in 2018 did not exist in 1998, so that differences between these two decades mostly reflect exit and entry, not survival. Second, note that considering all firms, average size increased from 4.8 to 5.6 workers, or almost 17% However, this was mostly accounted for by large firms: 253.3 workers in 2018 vs. 215.6 in 1998. Very small firms had almost the same number (1.9 vs. 1.8), and small and medium ones actually had fewer. In turn, recall that large surviving firms hardly grew, so that the increase in their average size is explained mostly by entry, not growth. In turn, this implies that practically all the increase in average firm size in these two decades resulted from the entry of large firms.[17]

Graph 5: Productivity distributions by range of size



Source: authors' calculations with Census data.

Third, it is evident that large firms are on average more productive: in both years they have the smallest left tail and the largest right one. This supports the association commonly made between firm size and productivity. That said, it is also evident that the distributions by size range overlap;

[17] As discussed before, very small and small surviving firms grew, but substantially more entered with a lower size, so that their average size in 2018 was almost the same as in 1998: 1.9 vs. 1.8 for the case of very small firms, and 7.3 vs. 7.5 in the case of small ones.

a fact that points out that there are some very small firms (and small and medium ones) with higher productivity than some large ones.[18]

Lastly, comparing the 1998 and 2018 distributions, note that the left tail contracted only for large firms and expanded for all others. This asymmetric behavior provides further insights into one of the main results of the Olley-Pakes decompositions presented before, namely, that entry was the single most important factor that depressed TFP between 1998 and 2018. The point here is that entry itself was heterogeneous: in the case of large firms, it increased size and TFP, but for the rest, it did neither.

Although for confidentiality reasons we cannot identify them individually, it is very likely that exporting firms are among the large high productive entrants, a result intimately associated with the trade liberalization efforts mentioned in the introduction. The 2018 census reports 11,387 firms that are direct exporters, who are on average 51 times larger than the average firm, 2.6 times more capital intensive, and pay 40% higher wages; see Levy and Fentanes (2022). Of these, 74% entered in or after 1994, when the North American Free Trade Agreement began.

VIII. Dynamic Olley-Pakes decomposition: manufacturing versus services and commerce

VIII.1 Firm dynamics and resource allocation

In this section we classify firms into manufacturing (denoted M) and services and commerce (R, for rest). We again use expressions (14) and (15) to decompose ΔTFP, simply substituting M for F and R for I. Table 8, analogous to table 5, describes firm dynamics (except that in this case there are no changes of sector within survivors). By construction, the totals for exit, survival and entry are the same as in table 5. A key point to note is that over this period the share of employment in manufacturing fell from 35.5 to 27.2%, and its share of capital from 45.4 to 40.5%.

Table 8: Firm dynamics by sector

	Starts 1998	**Exit**	**Survival**	**Entry**	**Ends 2018**
Manufactures	317,879	270,236	47,643	356,597	404,240
Rest	2,228,882	1,810,458	418,424	3,222,416	3,640,840
Total	**2,546,761**	**2,080,694**	**466,067**	**3,579,013**	**4,045,080**

Source: authors' calculations with Census data.

[18] In fact, in absolute numbers there substantially more very small high productivity firms than large ones. For example, for 1998, 2.8% of 2,313,982 exceeds 41% of 24,342 (64,791 vs. 9,980).

VIII.2 Results

Table 9 presents factor shares, the weighted productivity of exiting, surviving, and entering firms and the contribution of each to ΔTFP. Four observations are of interest. First, productivity in manufacturing is higher than in services and commerce and, more importantly, the gap increased. Since the main difference between them is their exposure to international trade, it is difficult to avoid the conclusion that the trade liberalization measures are mainly responsible for the relatively better performance of manufactures. This conclusion is buttressed by the asymmetries in the behavior of productivity among surviving firms: in manufacturing it increased by 12.2% (= $P_{SM2} - P_{SM1}$), while in the other sectors it fell, by 20% (= $P_{SR2} - P_{SR1}$); differently put, services and commerce fully account for the productivity fall among surviving firms. It is also buttressed by the fact that in manufacturing, entering firms are more productive than exiting ones ($P_{EM} > P_{XM}$), while the opposite occurs in services and commerce ($P_{ER} < P_{XR}$). And, finally, it is buttressed by the fact that entering firms are substantially more productive in manufacturing than in services and commerce ($P_{EM} > P_{ER}$).

Table 9: Factor shares, firm productivity by sector and ΔTFP

		Factor Shares		Weighted Firm Productivity		Contribution to
		1998	2018	1998	2018	ΔTFP
	M	$v_{XM} = 0.157$		$P_{XM} = 4.246$		0.061
Exit	R	$v_{XR} = 0.513$		$P_{XR} = 4.056$		0.296
	All	$v_X = 0.670$		$P_X = 4.103$		0.357
	M	$v_{SM1} = 0.119$	$v_{SM2} = 0.088$	$P_{SM1} = 4.857$	$P_{SM2} = 4.979$	0.363
Survival	R	$v_{SR!} = 0.209$	$v_{SR2} = 0.118$	$P_{SR1} = 4.507$	$P_{SR2} = 4.302$	(-) 0.407
	All	$v_{S1} = 0.328$	$v_{S2} = 0.206$	$P_{S1} = 4.634$	$P_{S2} = 4.590$	(-) 0.044
	M		$v_{EM} = 0.173$		$P_{EM} = 4.530$	(-) 0.010
Entry	R		$v_{ER} = 0.620$		$P_{ER} = 3.980$	(-) 0.378
	All		$v_E = 0.793$		$P_E = 4.102$	(-) 0.388
Total		1.000	1.000	4.273	4.199	(-) 0.074

Source: authors' calculations with Census data.

In other words, overtime manufacturing behaved differently, better than services and commerce. That said, note that entering manufacturing firms are less productive than surviving ones ($P_{EM} < P_{S2}$), a phenomenon due to the fact that entry of informal low productivity firms into manufactures was large.[19]

Second, while manufacturing performed better, its factor share fell from 27.6% in 1998 (= $v_{XM} + v_{SM1}$) to 26.1% in 2018 (= $v_{SM2} + v_{EM}$). This finding is clear evidence of misallocation across sectors, as the high productivity sector of the economy contracted. It also implies that from the point of

[19] There were 317,879 manufacturing firms in 1998, 79,258 formal and 238,621 informal. Of these, 47,643 survived to 2018, 16,346 formal and 31,297 informal. Among surviving firms, 5,999 transited from formal to informal, and 2,216 in the opposite direction. In parallel, 46,921 formal and 309,676 informal firms entered, yielding a total of 404,240 firms in 2018, 59,484 formal and 344,756 informal. Note that among surviving firms more transited from formality into informality than vice versa; almost by a ratio of three to one.

view of TFP, the performance of services and commerce is extremely relevant, and that when they underperform, they punish TFP considerably.[20]

Third, contrasting tables 6 and 9, it is clear that regardless of whether we consider exit, survival, or entry, the differences in productivity between formal vs. informal firms are larger than those between firms in manufacturing vs. services and commerce, and in all cases by large margins. This observation is critical because it highlights that from the point of view of TFP, the contractual differences between firms matter substantially more than their differences in exposure to international trade. As we show below, TFP would increase much more in Mexico closing the productivity gap between formal and informal firms than by closing it between firms in manufactures versus the other two sectors.

Finally, we describe the contribution of each sector to ΔTFP. Exit in manufacturing raised TFP by 6.1% while services and commerce by 29.6%. The exit of manufacturing firms contributed little because their productivity was higher ($P_{XM} > P_{XR}$), and because the resources involved were substantially smaller ($v_{XM} < v_{XR}$). In parallel, as noted, services and commerce fully account for the 4.4% fall in productivity among survivors. Finally, firms in services and commerce almost fully account for the negative contribution of entry to ΔTFP: (-) 37.8% vs. (-) 1% for manufacturing; a result due to the fact that their factor share was higher ($v_{ER} > v_{EM}$) and the gap vis-à-vis the productivity of surviving firms was larger [that is, in absolute values, ($P_{S2} – P_{ER}$) > ($P_{S2} – P_{EM}$). In the end, during the two decades considered here, manufacturing played a relatively modest role in the changes in TFP; services and commerce had the upper hand.

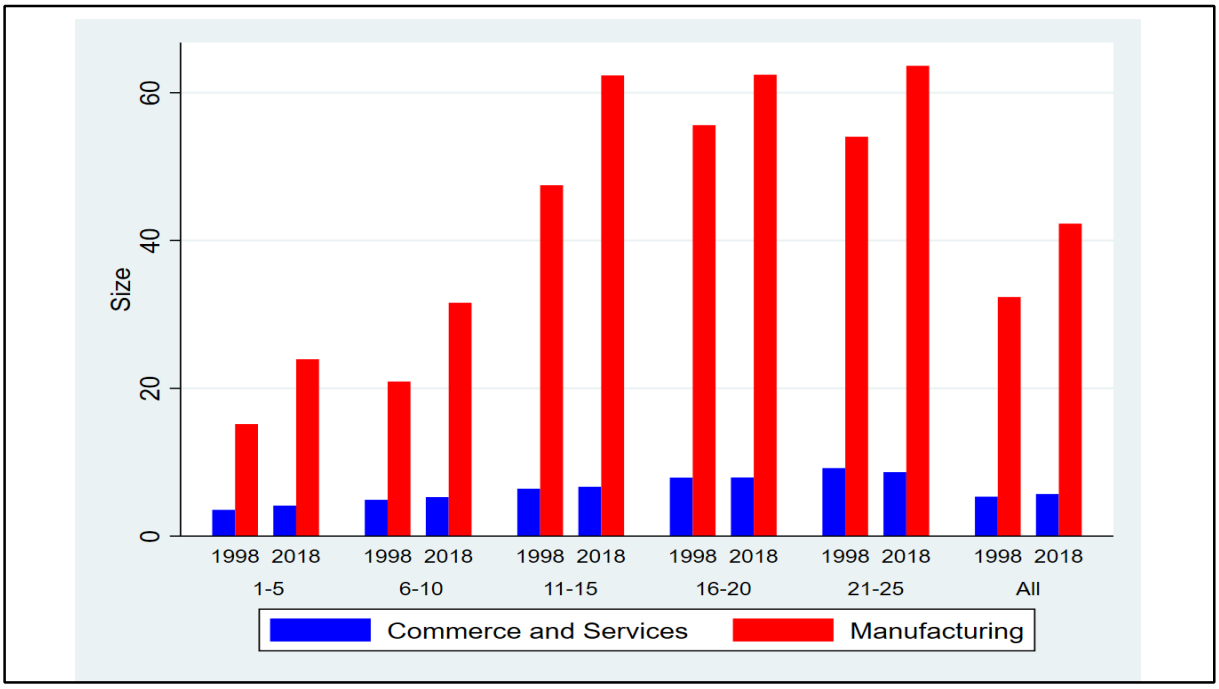
VIII.3 Firm growth

We close this section discussing firm growth from the sector perspective, focusing again on surviving firms. Note from table 8 that out of the 466,067 surviving firms, only 47,643 are in manufacturing (≈10%). With that observation, the horizontal axes in graph 6 groups firms by sector and age in 1998 (between one and five years old, six and ten, and so on). The vertical axes shows their size, given by the number of workers.

Considering firms in all sectors, average size increased by 16%, from 8 to 9.3 workers (table 7). However, graph 6 shows that the differences between manufactures and services and commerce are dramatic and widened in these two decades. Average size in manufactures was 32.4 in 1998 and 42.3 in 2018, an increase of 30%; in contrast, in services and commerce it was 5.3 and 5.7, respectively, an increase of 7.5%. Differently put, the 16% increase in the size of surviving firms was basically driven by manufactures (despite the fact they represented only 10% of survivors).

[20] The share of manufactures in GDP fell from 18% in 1998 to 15.3% in 2018. Our results are consistent Rodrik's (2016) 'premature deindustrialization' hypothesis. What is notable in Mexico's case is that deindustrialization occurred despite the very successful performance of manufacturing exports.

Table 6: Size of surviving firms: manufacturing vs. services and commerce



Source: authors' calculations with data from the Economic Census.

Thus, graph 6 provides further evidence that manufactures behaved differently than services and commerce. As shown before, it was the only sector to make a positive contribution to ΔTFP and, as shown here, firms grew substantially more. Unfortunately, as already noted, manufactures was unable to increase its share of resources and despite its relatively better performance, TFP fell.

IX. Two back-of-the envelope calculations: formality vs. sector composition

What would have happened to TFP if between 1998 and 2018 the formal-informal segmentation of the economy had disappeared? Answering this question requires a model capturing the impact of the institutions alluded to in section II on firm and worker behavior. Clearly, changing them would impact occupational choices, the size distribution of firms, the dynamics of entry, survival, and exit, the patterns of firm growth, and incomes and the size of the market, among many variables. An exceedingly difficult task not attempted here.

Rather, in this section we carry out two mechanical exercises. In the first one we assume that between 1998 and 2018 the productivity of informal surviving firms converges to that of formal surviving firms, and the productivity of entering informal firms equals that of entering formal ones. The exercise is equivalent to a scenario where the market share of informal firms falls from 24% to 0%, so that formal ones make all investments, hire all workers, and produce all goods and services. In this scenario, between 1998 and 2018 TFP would have increased by 27%, for an annual

growth rate of 1.2%.[21] This result compares to the annual growth rate of (-) 0.3% estimated in section VI and provides another angle on the extent to which informal firms depress productivity growth.

In the second exercise we assume that between 1998 and 2018, the productivity of surviving and entering firms in services and commerce converges to that of manufacturing. In this case, TFP would have increased by 12.3%, less than half of the increase in the 'no informality' case. This result is explained by the fact that in this case TFP continues to be punished by the presence of informal firms and supports the following observation: from the point of view of TFP, the formal-informal composition of the economy matters substantially more than its sector composition.

X. Conclusions

In this paper we exploited a very rich and, by Latin American standards, unique firm database, to understand why, despite many reforms to increase efficiency and a boom in manufacturing exports, TFP fell in Mexico in the last decades. We have six results: first, between 1998 and 2018 firm informality increased in the aggregate and in most six-digit sectors, productivity differences between formal and informal firms widened, and the distribution of firm productivity polarized. In parallel, the market share of formal firms increased in manufacturing, fell in services and commerce, and increased marginally in the aggregate, from 76 to 77%.

Second, using a 20-year panel to study firm dynamics, we find large churning: eight out of ten firms present in 1998 exited before 2018 and nine out of ten in 2018 entered after 1998. However, this churning was useless as TFP fell 7.4%. Exit raised TFP because many unproductive informal firms exited, although troublingly some higher productivity formal firms also exited. Survival lowered TFP because, on balance, the productivity of surviving firms fell. Entry also lowered TFP because many informal low productivity firms entered; in fact, very poor selection at entry was the single most important factor punishing TFP. All in all, firm dynamics were dysfunctional.

Third, for each surviving informal firm that formalized, two surviving formal ones informalized. Only 5% of surviving informal firms followed the expected path of "growing, formalizing and becoming more productive"; the remaining 95% neither grew, nor formalized nor became more productive. Further, formal firms that survived by informalizing became less productive. Altogether, the relation between changes in size of surviving firms and changes in their productivity was the opposite of what was expected, as average size increased but productivity fell.

Fourth, the increase in average firm size between 1998 and 2018 was driven almost exclusively by the entry of relatively few large firms. Surviving medium and large firms hardly grew,

[21] Interestingly, this growth rate –though still lower than that observed in many East Asian countries-- would have exceeded that of Canada (0.26%) and the United States (0.66%) over the same period. In other words, rather than divergence, there would have been convergence in TFP between Mexico and its Nafta partners.

particularly in services and commerce, and many small firms entered. As a result, the distribution of firm size also polarized.

Fifth, manufacturing behaved differently than services and commerce, as its TFP increased while it fell in the other two sectors. That said, its performance was far from stellar because despite the many measures promoted to increase efficiency, informal entry into manufacturing continued. Moreover, its contribution to aggregate TFP was diluted because, despite being the higher productivity sector, its share of resources fell.

Finally, we find that productivity differences between formal and informal firms are larger than those between firms in manufacturing and other sectors, implying that from the point of view of TFP, the formal-informal composition of the economy matters more than the sector composition.

Our findings are based on an extension of the dynamic Olley-Pakes productivity decomposition proposed by Melitz and Polanec (2015) to an economy with a large informal sector. As opposed to the "Solow residual" obtained from an aggregate production function, the O-P decomposition studies the path of TFP following the patterns of exit, survival and entry of individual firms. The Solow residual is usually thought of as a black box; "a measure of our ignorance". This contrasts with the O-P decomposition, where changes in TFP are derived from the performance of individual firms; in our case, over 6.5 million. The O-P decomposition sheds considerable light on the behavior of TFP in Mexico because it highlights the critical role played by resource misallocation across and within sectors.

When firms are classified by sector, the Olley-Pakes decomposition highlights the asymmetric behavior of manufactures versus services and commerce, and calls attention to the fact that while manufacturing TFP may increase, aggregate TFP can fall. While it is often the case the data limitations preclude analysis of productivity in services and commerce, this finding suggests caution when extrapolating the results of studies focused only on manufacturing. In contexts of large misallocation, manufacturing TFP may increase while its share of resources falls, and its positive contribution to aggregate TFP may be offset by the negative contribution of other sectors, as was the case in Mexico.

In parallel, when firms are classified by formality status, the Olley-Pakes decomposition highlights the fact the TFP can increase in the formal sector and fall in the informal one. Again, while it is often the case that data limitations preclude analysis of informal firms, this finding suggests caution when extrapolating the results of analysis of TFP that focus only on formal ones. Any individual informal firm is almost irrelevant; jointly they can make all the difference, as was also the case in Mexico.

Finally, the Olley-Pakes decomposition provides a useful complement to analyses of the impact of individual policies on TFP. Undoubtedly, the advantage of these analysis is that they carefully identify the impact of a single policy and the mechanisms through which it impacts TFP. However, by focusing on an individual tree, they miss the interaction with other trees, an extremely relevant consideration when other trees behave differently from the tree under study and may determine

the fate of the forest. The point here is that to obtain a fuller understanding of the determinants of changes in aggregate TFP, we need both: studies of individual policies with techniques that allow to identify causality, and studies of how multiple policies interact and determine the overall outcome, even if one cannot identify the individual contribution of each, as this paper attempted.

Our findings have substantive implications for policy in Mexico and, we would argue, for countries with large informal sectors. First, they highlight that from the point of view of TFP, the formal-informal segmentation of the economy is very costly, and that this segmentation can persist and in fact increase even in the context of reforms like privatizations, creation of regulatory bodies to promote competition, and trade liberalization.

Second, they reflect the inconsistent nature of the policymaking process in Mexico. At the end of the day, the dysfunctional nature of its firm dynamics in the period studied here show that the efficiency-enhancing reforms promoted since 1990 to increase TFP could not counteract other forces in the economy operating in the opposite direction.[22]

Third, they highlight that, ignoring social protection issues, informality is a "market competition problem". Informal firms survive or are continuously created because they can adapt to shocks with more ease than formal ones; and because they are implicitly subsidized by the dual nature of the Mexico's social insurance architecture, and by special tax regimes. In parallel, formal firms have more difficulty responding to shocks, and are implicitly taxed by flaws in the social insurance regime and by enforcement of regulations proportional to firm size; as well as hindered by a weak contracting environment. Because formal and informal firms co-exist in most narrowly defined markets, the result is that competition is heavily distorted, weakening the connection between firm size, firm growth, and productivity. The point here is that this "market competition problem" could not be addressed by the privatization of state-owned enterprises and the trade liberalization measures promoted by Mexico, including its fourteen trade agreements; and was legally beyond the reach of the anti-trust authorities that were created in parallel.

Fourth, our findings indicate that successful export performance, particularly in manufacturing, need not always be an 'engine of TFP growth'. This is not to say that manufacturing exports are not welcome; they are, and without them Mexico's productivity performance would have been even more dismal. But it is to say that they cannot offset the institutions and policies that generate the formal-informal divide. Mexico's experience is thus a cautionary tale not in the sense that countries with large informal sectors should not open to international trade, but in the sense that, in parallel, they need to do much more to fully reap its benefits. Differently put, trade reform or, for that matter, privatizations or anti-trust policies, are not a substitute for tackling the roots of the formal-informal divide, and the first without the second can result in a situation where a segment of the economy performs very well, and the rest stagnates.

[22] Levy (2018) documents that between 1998 and 2018, tax, labor and social insurance regulations changed, favoring informality, at the same time that the contracting environment faced by firms deteriorated.

Fifth, policymakers often pay large attention to manufacturing, hoping that improving its performance will increase aggregate TFP: industrial or productive development policies, credit from development banks, subsidies for R&D, free trade areas, and so on. However, our findings underline the importance of focusing on services and commerce. These sectors can more than offset manufacturing's positive behavior, more so if their share of resources increases. Differently put, to increase aggregate TFP, policymakers need to pay attention to services and commerce, even if this is more challenging because informality in these sectors is more prevalent.

One last word. Over the last two decades our understanding of the causes and consequences of informality has significantly increased.[23] While there are still gaps in our knowledge, research indicates that the institutions mentioned in section II play a central but not exclusive role, although their relative importance varies across countries. This research was not available when Mexico began its reform process in the early 1990s, and it is understandable that policymakers back then focused on trade reform, domestic competition policy, and privatization of state-owned enterprises, as the best route to increase TFP and accelerate growth. But we now know that the formal-informal segmentation of the economy is central for TFP, and that it did not fade away as a result of the reforms promoted by Mexico in the last decades. We know, differently put, that the roots of informality need to be tackled directly if countries with economic structures similar to Mexico's want to experience faster productivity growth.

[23] For reviews, see Ulyssea (2020) and Levy and Cruces (2021)

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