Productivity, exit and crisis in manufacturing and service sectors

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Abstract

Using micro data from manufacturing and several services sectors we estimate the relationship between firm exit and firm productivity. We found that even during profound crisis years, when the financial sector collapsed, exit of firms is associated with lower productivity. This suggests that even in the presence of severe financial frictions cleansing effects dominates scarring or sullying effect of recessions.

Keywords: tfp, crisis, cleansing effects
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1. Motivation

In recent years, several authors have studied productivity differentials at the industry, firm and plant level.[1] Their studies reveal that, in addition to productivity enhancing investments, capital and labor reallocation from less to more efficient establishments constitute an important source of productivity growth.

Since the second half of the twentieth century the business cycle fluctuations of developed countries tended to be substantially smoother than fluctuations in less developed countries (LDC). The current crisis in some European countries and the US suggest that they might benefit from learning form LDC countries past experiences where episodes of sharp declines in GDP and sever distortions to the functioning of their markets have been more common. Moreover, microdata of firm dynamics for developed countries suffering profound financial crisis is still not available. This type of data is available from LDC.

While most studies have been conducted for developed economies, a few studies suggest that reallocation is also an important source of productivity growth in developing economies. Probably due to data availability, almost all studies focus only in manufacturing. This is a shortcoming of the current literature that is unable to have a more encompassing picture of the economy including other sectors.

In this paper, using data from manufacturing and service sectors for Uruguay we seek to evaluate the effect of a deep economic and financial crisis in the relation between firm survival and total factor productivity and addresses whether the market performs relatively well in selecting the most productive for survival or not.

Schumpeter's creative destruction process was the framework for the traditional view that recessions improve resource allocations by driving out less productive firms. Davis and Hatiwanger (1992) show that job reallocation increases during recessions, which has been interpreted as evidence of the former. Several theoretical papers try to explain this pattern.[2] The basic intuition behind these models is that during recessions profitability decreases for all firms, therefore those firms at the bottom of the productivity distribution exit. The empirical evidence is less clear than these theoretical predictions yielding doubts on how efficiently markets destroy jobs and force firms to exit. For instance Griliches and Regev (1995) and Baily, Bartelsman and

[1] See for instance Syverson, (2004a and 2004b), Foster, Haltiwanger and Syverson (2008), Eslava et al (2004). In this journal see for instance Gandelman et al (2011)

Haltiwanger (2001) find only weak evidence that the contribution of reallocation to aggregate productivity change is countercyclical.

This motivated more theoretical work pointing that besides the cleansing effects there may be other effects playing in opposite direction during recessions. Barlevy (2002) introduces on-the-job search and demonstrates that this gives rise to a "sullying" effect that works against the cleansing effect. Barlevy (2003) argues that in the presence of credit market frictions, resources may be reallocated to the less efficient firms. His basic argument is that more productive firms may be more credit demanding and in times of credit crunches they may suffer more from the recession. In a very illustrative exemplification, Barlevy explains that although cockroaches are note more efficient than other animals in finding food they are more likely to survive harsh climactic episodes because they require less. In the same fashion when credit becomes scarce, those who require less of it are more likely to survive independently of efficiency considerations.

After the Brazilian devaluation of 1999, Uruguay suffered a recession that had its trough in 2002. In that year, Uruguay endured a profound financial crisis triggered by contagion effects from a depositor run on banks, massive currency devaluation, and large scale default on sovereign debt in next-door Argentina. In the wake of a run on its own exceedingly dollarized banking system, Uruguay's government was forced by the ensuing loss of international reserves to let the currency depreciate rapidly. Subsequently, it had to provide support to some financial institutions and several failing private-sector banks were intervened, obtaining massive financial backing from the Washington-based multilateral agencies to that end. Eventually, the government also had to arrange for a market-friendly restructuring of the public debt. The fall-out of this crisis on the local capital markets was such that the volume traded in the traditional stock exchange fell by 14% in 2002 measured in US dollars (USD), while volumes in the electronic exchange dropped by more than half. Starting in the fourth quarter of 2003, however, the Uruguayan economy staged a vigorous recovery and the government regained access to domestic and international capital markets.

Even accepting the more positive cleansing effect, the empirical literature has focused on times of relatively normal economic conditions that were not present in Uruguay during the 2002 crisis or in later crisis of several European countries. If there is a systemic crisis and the financial

[2] See for instance Hall (2000), Mortensen and Pissarides (1994) and Caballero and Hammour (1994, 1996).

system collapses, how does the market perform? Was the crisis magnified through exit of underperforming firms or is it that exit during profound systemic crisis is relatively independent of productivity?

This papers contributes to the literature in several ways: i) it tests the existence of cleansing effects during a financial market breakdown, ii) besides manufacturing it uses data from services sectors, iii) it focuses on a less developed country were markets in general perform worse than in developed countries.

2. Measuring Total factor productivity

To measure productivity we implement the Levinsohn-Petrin (2003) methodology to obtain total factor productivity at the firm level by estimating the production function parameters.

The LP methodology has been widely used in recent years to measure total factor productivity using microdata. It intends to control for unobservables and is based on a proxy variable. We use energy consumption to control for the simultaneity problem in production function estimation (the input choice of firms conditional on the fact that they continue to be in activity depends on their productivity).[3]

Our basic Cobb-Douglas estimated equation is

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \omega_{it} + \nu_{it}$$

where y_{it} is firm i's value added in period t, l_{it} is labor and k_{it} is capital (all in logs); ω_{it} is productivity, observed by the firm but not by the researcher, while v_{it} is an error term not correlated with factor choices by the firm. Our TFP estimation is obtained as:

$$tfp_{sit} = y_{it} - \hat{\beta}_l l_{it} - \hat{\beta}_k k_{it}$$

where tfp_{sit} is (log) of TFP of firm i in industry s in period t. Details of the estimation procedure are given in the Appendix.

[3] Casacuberta, Fachola and Gandelman (2004) compares the estimations of LP methodology and Olley and Pakes (1996) using data from the Uruguay manufacturing sector. The results are similar.

To describe and characterize TFP evolution at a sector level, it is usual to calculate sector level weighted averages using

$$tfp_{st} = \sum_{i \in s} \phi_{sit} tfp_{sit}$$

Instead of taking ϕ_{sit} as firm i's share in sector s's value added we prefer to take ϕ_{sit} to be equal to $1/n_t$, i.e. the inverse of the number of firms in the sample in period *t*, [4]

2.1.Data

We use the Encuesta Anual de Actividad Económica (Economic Activity Survey) 1997-2005 from the National Statistics Institute (INE) containing annual firm level observations. The survey-sampling frame encompasses Uruguayan firms in a wide number of 4-digit ISIC sectors including, apart from manufacturing, a wide number of services and commerce sectors.

The survey was based on the 1997 Economic Census. Within each four-digit International Standard Industrial Classification (ISIC) sector, all firms with more than 50 employers were included in the survey, and a probabilistic sample was drawn from the set of firms with less than 50 employees.[5] The survey adequately covers the following sectors (according to ISIC Rev. 3): D-Manufacturing, E- Electricity, gas and water, G-Commerce, H-Hotels and restaurants, I-Transportation and communication services, K- Real estate & renting, M-Educational services, N-Health services, and O-other community, social and personal services. Table 1 reports the number of observations classified by size (as measured by the number of employees in 1997) that entered our TFP estimation.

[4] Being our dependent variable the log of constant price value added, TFP is measured in such units.
[5] For a detailed discussion see INE (1997).

Table 1. Number of firms and employment by firm size (number of employees) in TFP calculations, year 1997

	Number of firms			Nuber of employees		
Firm size (employment)	Number of firms	Share of total	Cumlative share	Number of firms	Share of total	Cumlative share
10 - 19	542	23,9%	23,9%	7772	3,7%	3,7%
20 - 49	844	37,2%	61,0%	27156	13,0%	16,7%
50 - 99	477	21,0%	82,0%	32639	15,6%	32,4%
100 - 249	269	11,8%	93,9%	40894	19,6%	52,0%
250 - 499	80	3,5%	97,4%	28461	13,6%	65,6%
500 - 999	39	1,7%	99,1%	26154	12,5%	78,1%
1000 or more	20	0,9%	100,0%	45650	21,9%	100,0%
Total	2271			208726		

Source: Economic Activity Survey data, INE

The INE tried to address the sample attrition problem that affected the Activity Survey samples in the past and periodically intended to revise the sample coverage and include new firms. The procedure was instrumented by an agreement with the Social Security Institute (Banco de Previsión Social) that provided a list of new firms to update the sample yearly. Unfortunately the list was not in practice available in all years. Thus, changes in the sample space are incorporated only in 2001, 2003, 2004 and 2005. It is important to note that the INE in practice did not redraw annually the random part of the sample, but rather included new firms without eliminating firms that did not close.

In 2002 numerous firms exited the market due to the economic crisis. The INE also suffered the effects of the crisis and data collection was implemented jointly with the 2003 survey. Records for 2002 are sometimes incomplete and firm information was collected in a more aggregated fashion than for the rest of the years.

Once a firm enters into the survey, it is followed until its death. Data for 1997 comes from the census and data for 1998 and after are obtained from the survey of economic activity. Thus, we do not know if a firm that reported in 1997 but not in 1998 ceased to exist or was simply not selected in the sample. Also, we do not know which firms exited after 2005. Hence, by construction, we do not have any exits in 1997 or in 2005. At any other point in time, when we have no more data for a particular firm, we interpret that as a plant closure (exit).

Dealing with entry also brings some difficulties for firms born after 1997. Birth date was gathered in the 1997 census but not in the following surveys. Therefore, we do not have that information for firms that entered the market after that date. In that case , we consider a firm to be born at time t if that is the first appearance in the database. Age is measured as the difference between the current year and the year it was born.

The panel includes consistent annual data on output, revenues, intermediate inputs, labor, capital and other expenditures. All variables except labor are expressed in 1997 Uruguayan pesos. For output and materials firm-specific deflators were computed by weighting the four-digit ISIC price indices with the share of each sector in firm's sales/costs. Other components of intermediate input consumption such as electricity, fuel and water were deflated by their individual price indices.

For the estimation of capital stock (for each relevant asset) the following equation was computed:

$$k_t = k_{t0}^{1997}(1-\delta)^{t-t_0} + \sum_{t_0+1}^{t} \frac{i_t}{ip_i}(1-\delta)^{t-t_0}$$

where k_{t0}^{1997} is the initial asset stock measured at 1997 prices , δ is a decay rate, i_t is current price investment, ip_i is the asset specific implicit deflator (computed using Central Bank of Uruguay data), and t_0 denotes the stock's initial year. δ was defined based on the values used by the U.S. Bureau of Economic Analysis (BEA).

3. Results

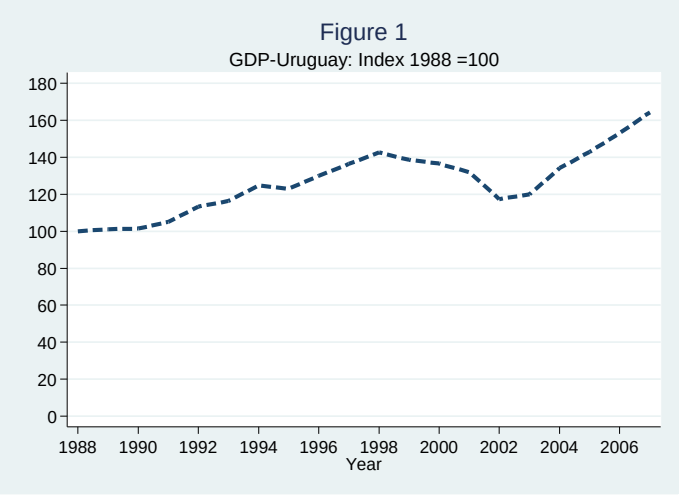
A salient macroeconomic feature of the period was a substantial exchange rate appreciation due to stabilization policies in the first half of the nineties. In 1995, a schedule was established for the Mercosur Common external tariff and intrazone tariffs were set to converge to zero, but the process allowed for many exceptions and was not fully carried through. The pace of economic growth slowed down and Uruguay went through a recession since 1999. The macroeconomic adjustment of Uruguay's neighbors led to a huge devaluation and financial crisis.

The financial crisis erupted in December 2001 when the Argentine government imposed capital controls and deposit freezes to Argentina's nationals. At that time, the two largest private banks in Uruguay began facing liquidity problems as a result of their high level of exposure to

Argentina. Argentinean depositors started to withdraw their funds and the run soon generalized to domestic depositors. By the end of July 2002, a cumulative and staggering 38 percent of total deposits had been withdrawn from the system. As the crisis was unfolding, the drastic and sustained deposit withdrawals translated into a system-wide credit crunch. Banks in desperate search for liquidity suspended new loans and requested early repayment of existing loans. Thus, credit to the non-financial sector shrunk by 37 percent during 2002 alone. The situation was stabilized with massive inflows from International Financial Institutions. Some banks had to close, and term deposits were compulsorily rescheduled.[6]

In 2002 GDP fell by 11% and unemployment rose up to 20%. The economic contraction was felt in almost all sectors. Manufacturing industry value added fell by 14%, construction by 22%, commerce by 25% and transportation by 9%. Only the agricultural sector rose by 5%. Considering the three years of recession the economy as whole shrunk by 18% (figure 1). After the crisis a strong recovery period started, and in 2003-2005 GDP grew 7% on average annually.

Figure 1. GDP-Uruguay: Index 1988=100

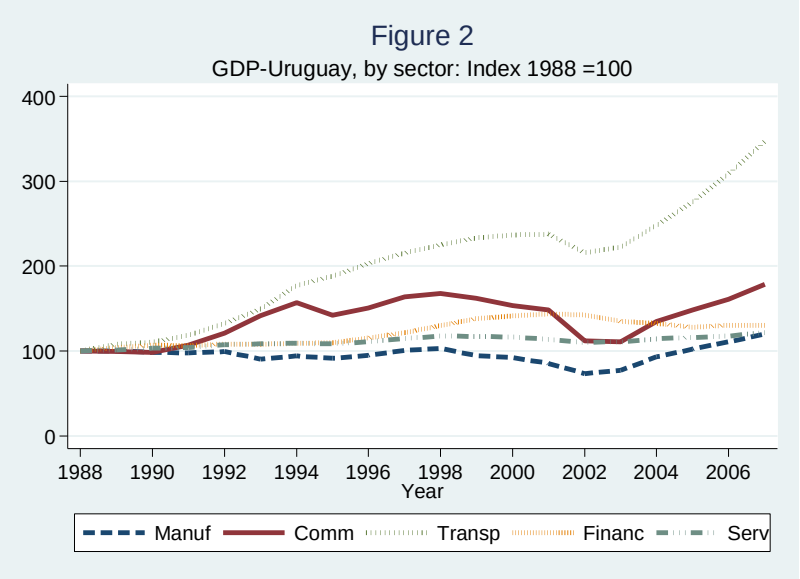


Source: Central Bank

The evolution of output has been dissimilar between sectors. The financial services sector (including insurance and services to firms) and the personal and social service sector did not in the aggregate experience the contraction suffered by other sectors in 2002. Recession was harder in commerce and manufacturing, and recovery more pronounced (see figure 2).

[6] See International Monetary Fund (2003); De la Plaza and Sirtaine (2005)

Figure 2. GDP-Uruguay, by sector: Index 1988=100



Source: Central Bank

Our micro data track such evolution. In the next table we present indexes and growth rates of sample means of value added and capital at constant prices and total employment. In the aggregate, the fall in output in 1999-2000 and 2002-2003 was accompanied by the reduction of labor usage and capital.

Table 2. Levels and growth rates of mean of value added, capital and employment
Firms with 10 or more employees

	Indexes of mean levels			Growth rates		
	Value added	Employment	Capital	Value added	Employment	Capital
1997	100,0	100,0	100,0			
1998	110,4	109,0	118,6	10,4%	9,0%	18,6%
1999	109,2	110,6	121,9	-1,1%	1,5%	2,7%
2000	116,3	112,7	128,5	6,5%	1,8%	5,4%
2001	115,4	103,2	116,6	-0,8%	-8,4%	-9,3%
2002	113,5	99,9	129,0	-1,6%	-3,2%	10,7%
2003	95,5	100,5	109,9	-15,9%	0,5%	-14,9%
2004	101,4	109,3	104,3	6,2%	8,8%	-5,0%
2005	109,3	115,2	102,9	7,8%	5,4%	-1,4%

Source: Economic Activity Survey

3.1. Production function estimation and TFP performance

Production function parameters were estimated separately within broad sectors, defined by the following ISIC categories: Manufacturing, Commerce, Restaurants and Hotels, Transport, Real estate & renting, Education, Health, and Other services. In the appendix a list of the included sectors is provided.[7]

We found it useful to change our specification across sectors to reflect technology and data characteristics. Our capital variable is the log of our estimation of total capital services, including buildings, except in the case of Manufacturing and Commerce, for which we used machinery capital. For the other sectors we used an aggregate capital measure including also buildings. For all sectors we obtained the value added version of the LP estimate. Table 3 presents the production function coefficients estimated.

Table 3. Production function, LP estimates.

Firms with 10 or more employees

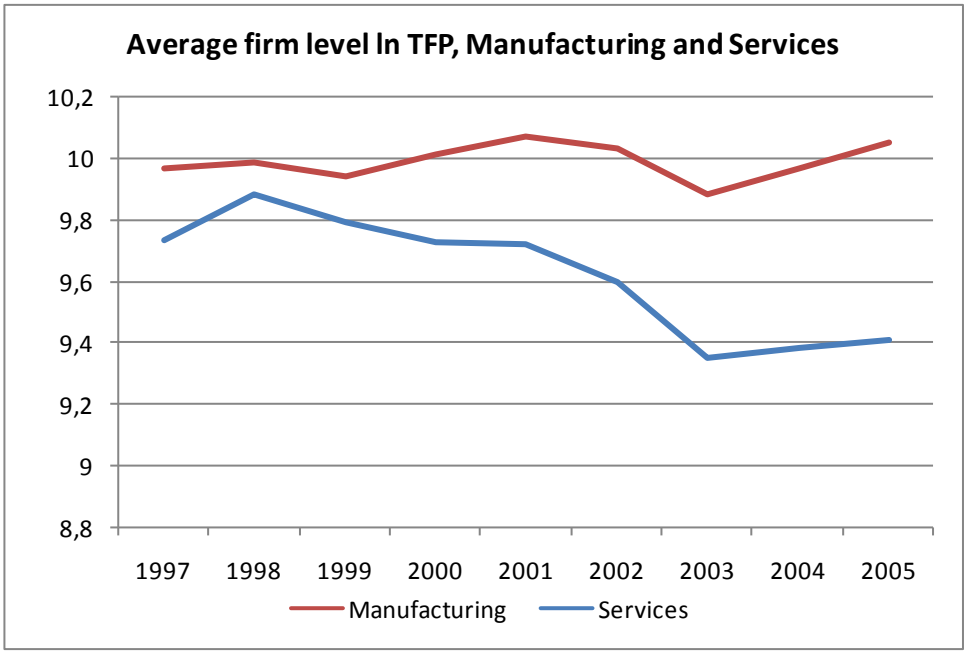
Dependent variable is value added Proxy variable: energy consumption							
Sector	Ln employment			Ln capital			Num Observ.
	Coeff	Sig	SD	Coeff	Sig	SD	
Manufacturing	0,81	***	0,04	0,18	***	0,06	5648
Commerce	0,98	***	0,05	0,15	***	0,04	6700
Hotels, restaurants	0,95	***	0,08	0,10		0,09	431
Transport	0,73	***	0,07	0,26	**	0,10	1554
Real estate	0,61	***	0,05	0,29	**	0,14	1128
Education	0,89	***	0,08	0,28	**	0,11	996
Health	0,69	***	0,09	0,13		0,11	927
Social care	0,68	***	0,12	0,04		0,16	64
Standard errors in parentheses generated after 200 bootstraps * Significant at 10%; ** significant at 5%; *** significant at 1%							

We obtain coefficients of acceptable magnitude and significance level to approximate firm technology in order to analyze the evolution of productivity. We use the derived firm level

[7] Alcohol beverages and tobacco industries were omitted since value added measures are distorted by specific sales taxes.

productivity measures to describe the sector-level total factor productivity evolution. We present if figure 3 the graph of average ln TFP by year. Figure 3 shows similar aggregate paths for manufacturing and services, being the fall associated to the crisis years deeper in the service sector and a slower latter recovery.

Figure 3. Sector level average total factor productivity



Aggregate results are affected by composition effects, hence the comparison of averages is sensitive to the effects of entry and exit. In table 4 we present the exit rate observed in our sample. Instead of a year-by-year table, we prefer to group years by defining three sub periods: the pre-crisis years (1998-2000), the crisis years (2001-2002) and post-crisis years (2003-2005). To do so we calculate exit rates between pairs of years at regular intervals: 2001 vs 1999, 2003 vs. 2001; and 2005 vs 2003. The exit rate accelerates in the crisis years.

Table 4. Exit rates

Firms with 10 or more employees

	Manufacturing				Services			
Period	con-tinuers	exit	total	exit rate	con-tinuers	exit	total	exit rate
1999-2001	550	98	667	14,7%	1168	159	1342	11,8%
2001-2003	514	136	648	21,0%	1228	258	1327	19,4%
2003-2005	503	66	613	10,8%	1133	158	1292	12,2%

Source: Economic Activity Survey

To reveal the impact of composition changes in the TFP pattern we can decompose the change in average ln TFP in its contributions by continuers, entry and exit, following the methodology proposed by Foster, Haltiwanger and Krizan (1998). The details are presented in the Appendix.

We calculate the difference in the average of log TFP, which is an approximation to the average TFP rate of growth. It can be written as the sum of the contribution of continuers, and the contribution of exiting and entering firms. Table 5 presents the decomposition results. Instead of a year-by-year decomposition, we prefer to group years by defining three sub periods: the pre-crisis years (1998-2000), the crisis years (2001-2002) and post-crisis years (2003-2004). Changes are measured between the first year of each period and the first of the next (1998 with 2001; 2001 with 2003; 2003 with 2005).

Table 5. . TFP growth decomposition

Table 5 Average TFP decomposition Foster, Haltiwanger, Krizan methodology								
Manufacturing								
	within	between	cross	continuers	entry	exit	temporary non responses	total
	(1)	(2)	(3)	(1) + (2) + (3)	(4)	(5)	(6)	
1999-2001	0,107	0,000	0,000	0,106	-0,009	0,002	0,033	0,132
2001-2003	-0,181	0,008	-0,026	-0,198	-0,048	0,019	0,037	-0,191
2003-2005	0,159	-0,002	-0,015	0,143	0,006	0,000	0,021	0,169
Services								
1999-2001	-0,044	-0,003	0,005	-0,042	-0,056	0,009	0,015	-0,074
2001-2003	-0,280	0,001	-0,042	-0,321	-0,057	0,007	0,001	-0,371
2003-2005	0,021	-0,003	-0,002	0,016	0,008	0,000	0,037	0,060

Our "entry" term includes few firms hence we do not interpret its evolution and provide it just for the sake of completeness. It can be observed that productivity changes in Uruguayan firms are driven by continuers which is to be expected being them the bulk of the firms.

We are particularly interested in the exit term. We calculate separately the effect of firms that exit from the effect of the firms that exit at one particular year but will later reenter (which we are interpreted as temporary non-responses). In both cases the impact in tfp growth goes in the same direction. This term are subtracted from TFP growth and are presented in the table so as to directly add all terms to obtain ln TFP growth. The exit terms represent the difference between the average productivity the period before and the aggregate of individual productivities of exiting firms . If they display as it is the case a positive sign this implies that exiting firms' are less productivite than the average. Thus their contribution, by exiting, to productivity growth is positive, i.e productivity would have grown less have this firms not exited.

We obtain evidence in the sense that the direction of the effect of exit on overall productivity is positive. This is a first set of evidence suggesting that the market is efficiently throwing out less efficient firms. In the crisis years the size of the exit contribution to TFP change of manufacturing firms is larger than before and after. In the service sector is about the same size than before and larger than the latter years. This suggests that even during the crisis years the market continued expelling the less productive firms. In the next section we will seek a direct estimate of the effect of productivity on firm exit.

3.2.Exit probabilities

We address market selection process by analyzing the exit probability conditional on total factor productivity and other firm characteristics. Firms with higher debt dependence or with accumulated deficit or borrowing are likely to exit, especially during financial crisis. To confirm that our results are not affected by financial crisis we include finance related variables to reflect market conditions.

Technological factors make some industries more dependent than others on external finance. Rajan and Zingales (1998) point that such factors include differences between industries in initial project scales, gestation and cash harvest periods and the requirement for continuing investment. They argue that these technological differences are likely to persist across countries, so an industry's dependence on external financing as identified in a given country could be used as a measure of its dependence in other countries. Following Rajan and Zingales (1998), Catão, Pagés and Rosales (2009) construct an external financing dependence index, using information from the sample of U.S. firms in the S&P 1500 index for the years 2000-2010.

The Catão, Pagés and Rosales (2009) external financing dependence (EFD) index is defined as the ratio between capital expenditures minus cash from operations (use of external finance) and capital expenditures. For each firm the ratio is calculated as the sum of external financial use for the 2000-2010 periods and the sum of capital expenditures for the same periods. A sector's financial dependence is calculated as the median index for the firms in that sector.

Our measure of EFD reflects difference between sectors in financial needs but does not present variation over time to capture movement in credit availability along the business cycle. Financial depening (FD) is the ratio of credit to the private sector to GDP, measured at the

country-year level, as a proxy for credit availability. We focus on banking credit because it is the most important source of external funding for firms in Uruguay (see for instance de Brun et al 2003 and 2008). The data source for credit is the Superintendency of Financial Services of the Central Bank of Uruguay (BCU).

The interaction of FD and EFD provides variation in the sector and time dimensions. It captures the impact of credit availability allowing for differential impact in sectors according to their external financial needs. A nice feature of our financial measure is that it can be considered exogenous to each individual firms' decision since from one part is based on data for the US and in another part is based on data for the whole country.

We estimate the following equation:

$$P(Exit_{it}) = f(\theta \ln TFP_{it} + \beta_1 Age_{it} + \beta_2 Age_{it}^2 + \sum \delta_j Size_{jt} + \lambda Exporter_i + FD_t EFD_j \sum \alpha_t d_t + \sum \gamma_k s_k + \varepsilon_{it}) \quad (6)$$

where ε_{it} is normal iid.

The dependent variable takes the value 1 if that is the last year the firm is observed in the sample, and $\ln TFP_{it}$, is the log of firm's TFP. In turn, Age_{it} indicates the number of years the firm is in activity, $Size_{it}$ is a set of size dummies equal to one if employment is 20-49, 50-99, 100-249 and ≥250 (the excluding category is 10-19 employees), $Exporter_i$ takes the value 1 if the firm exported during the sample years, d_t is a set of year dummies, and s_k are sector dummies. FD_t is the measure of financial deepening and *EFDj* is the Rajazn Zingales measure of external financial dependence.

Exit probabilities are related more generally to firm performance fundamentals and demand conditions so this regression must be interpreted as an exploratory step. Results are presented in Table 6.

Table 6. Determinants of firm exit, random effects probit regression
Dependent variable equals 1 if the period is the last the firm is present in the sample

	Manufact	Services	Manufact	Services
Log (TFP)	-0.2017***	-0.1920***		
	(0.049)	(0.043)		
Pre-crisis * log(TFP)			-0.2228***	-0.2595***
			(0.071)	(0.065)
Crisis * log(TFP)			-0.2614***	-0.1503***
			(0.089)	(0.057)
Post-crisis * log(TFP)			-0.1288*	-0.1788***
			(0.078)	(0.057)
Age	-0.0356***	-0.0072**	-0.0355***	-0.0076**
	(0.009)	(0.003)	(0.009)	(0.003)
Age^2	0.0004***	0.0000	0.0004***	0.0000
	(0.000)	(0.000)	(0.000)	(0.000)
Employment 20-49	-0.6677***	-0.7879***	-0.6638***	-0.8084***
	(0.132)	(0.119)	(0.132)	(0.124)
Employment 50-99	-0.8126***	-1.1867***	-0.8042***	-1.2147***
	(0.175)	(0.189)	(0.175)	(0.196)
Employment 100-249	-1.0115***	-1.4283***	-1.0053***	-1.4685***
	(0.220)	(0.255)	(0.221)	(0.264)
Employment $\geq$ 250	-1.1550***	-1.1351***	-1.1534***	-1.1577***
	(0.275)	(0.256)	(0.275)	(0.263)
Exporter	-0.0878	-0.4942***	-0.0891	-0.5087***
	(0.098)	(0.152)	(0.098)	(0.157)
FD*EFD	-0.0002	-0.0410***	-0.0001	-0.0409***
	(0.008)	(0.012)	(0.008)	(0.012)
Constant	-46.005	-59.938	-65.323	-78.713
	-609.226	-581.079	-704.917	-515.689
Observations	4,891	10,067	4,891	10,067
Number of firms	904	1,828	904	1,828

Note: Includes year and sector dummies. Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Pre-crisis=dummy for 1998-2000, Crisis=dummy for 2001-2002, Post-crisis= dummy for2003-2004

Our results recover a strong association between firm level total factor productivity and exit probabilities, confirming the result that the least productive firms tend to exit the market more likely. Also as expected we find that the firm's age has a decreasing effect in exit probabilities. We include the square term of age to capture non linearities. Our results suggest that in the manufacturing sector the effect of age on the probability of exit is concave with a reversal of the relationship age exit for old firms (about 445 years old). In services the square term resulted not significant, thus the older the firm the lower the probability of exit. Size in turn reduces a firm's exit probability. Being an exporter in manufacturing does not affect significantly

the probability of exiting while for the services sectors exporter firms have lower probability of exit. The lack of significance in manufacturing might be due to our exporter measure being too broad (any firm that ever exported anything is considered an exporter in the estimation). The financial variables have the expected sign but are only significant in services. The probability of exit of firms in sectors of higher external financial needs decreases when credit availability increases.

We test if the sign of the effect of productivity in the exit probabilities changed through time and interacted our TFP measures with year dummies from 1999 to 2004, obtaining a negative statistically significant sign for most years (not reported). We prefer instead to present our results grouped by interacting our TFP measures with time dummies that take the value 1 in the pre-crisis years (1998-2000), the crisis years (2001-2002) and post-crisis years (2003-2004). Note that a dummy in 2001 and 2002 means that this is the last year in which the firm was in activity, i.e. the firm exited in 2002 or 2003 respectively.

According to Table 6 the negative relationship between the TFP level and the probability of exit holds both for manufacturing and services. When we adopt a flexible specification allowing the TFP coefficients to vary along subperiods corresponding to the crisis years and those immediately after and before, we observe that low productivity firms were always more likely to exit, in the crisis years as well as in the pre and post crisis periods (negative sign and similar quantitative magnitude). We interpret this as evidence of the sorting process in which markets sort out the less efficient firms even during profound crisis periods when the financial markets are severely underperforming. Therefore, cleansing effects empirically dominate other effects that may run in opposite directions.

4. Conclusions

We sought to study how the profound Uruguayan crisis of 2002 affected the interrelation between resource allocation, productivity and firm survival. We believe that evidence of LDC that have suffered in the past large scale crisis may shed light on economic crisis being suffered by more developed countries in the later years.

We found that the market performs well in selecting the most productive firms for survival. The larger the productivity the lower the probability that a firm exits, even during the crisis

years. Exit of firms in that year was much larger than in other years but the firms that did not survive the crisis were relatively less productive than those surviving. Therefore, even during profound crisis when the financial market crushes and there is almost no credit available cleansing effects explain the pattern of firm exit and firm survival.

5. References

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6. Appendix

6.1. Sectors included in TFP estimations

Table A1.
2 digit ISIC sectors included in the TFP estimaton

ISIC Code	Description
D	MANUFACTURING
15	Manufacture of food products and beverages
17	Manufacture of textiles
18	Manufacture of wearing apparel; dressing and dyeing of fur
19	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, arness and footwea
20	Manufacture of wood and of products of wood and cork, except furniture; anufacture of articles of straw and plaiting materials
21	Manufacture of paper and paper products
22	Publishing, printing and reproduction of recorded media
23	Manufacture of coke, refined petroleum products and nuclear fuel
24	Manufacture of chemicals and chemical products
25	Manufacture of rubber and plastics products
26	Manufacture of other non metallic mineral products
27	Manufacture of basic metals
28	Manufacture of fabricated metal products, except machinery and equipment
29	Manufacture of machinery and equipment n.e.c.
30	Manufacture of office, accounting and computing machinery
31	Manufacture of electrical machinery and apparatus n.e.c.
32	Manufacture of radio, television and communication equipment and apparatus
33	Manufacture of medical, precision and optical instruments, watches and clocks
34	Manufacture of motor vehicles, trailers and semi trailers
35	Manufacture of other transport equipment
36	Manufacture of furniture; manufacturing n.e.c.
G	WHOLESALE AND RETAIL TRADE; REPAIR OF MOTOR VEHICLES, MOTORCYCLES AND PERSONAL AND HOUSEHOLD GOODS
50	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel
51	Wholesale trade and commission trade, except of motor vehicles and motorcycles
52	Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods
H	HOTELS AND RESTAURANTS
55	Hotels and restaurants

I	TRANSPORT, STORAGE AND COMMUNICATIONS
60	Land transport; transport via pipelines
61	Water transport
62	Air transport
63	Supporting and auxiliary transport activities; activities of travel agencies
64	Post and telecommunications
J	FINANCIAL INTERMEDIATION
66	Insurance and pension funding, except compulsory social security
K	REAL ESTATE, RENTING AND BUSINESS ACTIVITIES
71	Renting of machinery and equipment without operator and of personal and household goods
72	Computer and related activities
73	Research and development
74	Other business activities
M	EDUCATION
80	Education
N	HEALTH AND SOCIAL WORK
85	Health and social work

6.2. Productivity growth decomposition

Average log TFP is defined as follows:

$$tfp_t^s = \sum_{i \in s} \phi_{it}^s tfp_{it}^s$$

where tfp_{it}^s is the log of TFP of firm *i* in industry *s* in period *t*, and ϕ_{it}^s is a weight which in our exercise is taken to be $1/n_t$, being n_t the number of firms in period t. It can be shown that sector mean log of TFP equals the log of a weighted geometric mean of the total factor productivity levels:

$$tfp_{it}^s = lnTFP_t^s = ln\prod_i \left(TFP_{it}^s\right)^{\varphi_{it}} = \sum_i ln\left[\left(TFP_{it}^s\right)^{\varphi_{it}}\right]$$

Hence the level TFP growth rate (dropping the sector subindex) can be written as:

$$\Delta tfp_t = tfp_t - tfp_{t-1}$$

Foster, Haltiwanger and Krizan (1998) propose the following decomposition equation:

$$\Delta tfp_t = \sum_{i \in C} \phi_{it-1} \Delta tfp_{it} + \sum_{i \in C} (tfp_{it-1} - tfp_{t-1}) \Delta \phi_{it} + \sum_{i \in C} \Delta tfp_{it} \Delta \phi_{it} + \sum_{i \in N} (tfp_{it} - tfp_{t-1}) \phi_{it} - \sum_{i \in X} (tfp_{it-1} - tfp_{t-1}) \phi_{it-1}$$

All firms that are active in both periods belong to C, firms that enter are in N and exiting firms are in X. The first term in this equation represents the within plant component while the second term represent the between plant component. The last two terms represent the contribution of entering and exiting establishments. [8]

6.3. Levinsohn-Petrin productivity estimation

Levinsohn-Petrin (2003), LP, set to estimate the parameters of a production function (in logs) given by:

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \omega_{it} + \nu_{it}$$

As stated above, y_{it} is firm i's value added in period t, l_{it} is labor and k_{it} is capital (all in logs); ω_{it} is productivity, observed by the firm but not by the researcher (and hence influencing firm's choices and leading to a simultaneity problem), while v_{it} is an error term not correlated with factor choices by the firm. LP note that the intermediate input demand (for instance, materials, energy consumption, etc.) is a function of both productivity and capital services (which in turn are firm's state variables):

$$m_{it} = m_{it}(k_{it}, \omega_{it})$$

LP show that under general assumptions such function is monotonically increasing in ω_{it} and hence invertible, obtaining:

$$\omega_{it} = h_{it}(k_{it}, m_{it})$$

The first stage estimated equation is

[8] Besides entry and exit, in our database there are some temporary non responses. We calculate separately their contribution to TFP growth.

$$y_{it} = \beta_l l_{it} + \phi_t(k_{it}, m_{it}) + \nu_{it}$$

where

$$\phi_t(k_{it}, m_{it}) = \beta_0 + \beta_k k_{it} + h_{it}(k_{it}, m_{it})$$

A polynomial in k_{it} and m_{it} is substituted by $\phi_t(k_{it}, m_{it})$ and the first stage equation is estimated by OLS, identifying the labor coefficient β_l.

In a second stage the capital coefficient is also identified. LP assume that productivity follows a Markov first order process, and then it holds:

$$\omega_{it} = E`[\omega_{it} | \omega_{it-1}] + \xi_{it}$$

where ξ_{it} is innovation in productivity, uncorrelated with k_{it} but possibly correlated with the firm's labor input. The estimated value for ϕ_t is given by:

$$\hat{\phi}_t = \hat{y}_{it} - \hat{\beta}_l l_{it}$$

This in turn, if a (candidate) value β^*_k is given to β_k, this allows to compute an estimation of firm level productivity ω_{it} product to be obtained as:

$$\hat{\omega}_t = \hat{\phi}_t - \beta^*_k k_{it}$$

A polynomial is used to estimate

$$\hat{\omega}_t = \gamma_0 + \gamma_1 \hat{\omega}_{t-1} + \gamma_2 \hat{\omega}^2_{t-1} + \gamma_3 \hat{\omega}^3_{t-1} + e_t$$

The residuals from this regression are a consistent approximation to $E`[\omega_{it} | \omega_{it-1}]$. The moment condition $E`[\xi_{it} | k_{it}] = 0$ is then used to search for the value of β_k that minimizes its sample counterpart.