Working Papers 2018

18

Every cloud has a silver lining: micro-level evidence on the cleansing effects of the portuguese financial crisis

Daniel A. Dias | Carlos Robalo Marques

BANCO DE PORTUGAL
EUROSYSTEM

Working Papers 2018 18

Every cloud has a silver lining: micro-level evidence on the cleansing effects of the portuguese financial crisis

Daniel A. Dias | Carlos Robalo Marques

JUNE 2018
The analyses, opinions and findings of these papers represent the views of the authors, they are not necessarily those of the Banco de Portugal or the Eurosystem

Please address correspondence to
Banco de Portugal, Economics and Research Department
Av. Almirante Reis, 71, 1150-012 Lisboa, Portugal
Tel.: +351 213 130 000, email: estudos@bportugal.pt

BANCO DE PORTUGAL
EUROSYSTEM

Lisbon, 2018 • www.bportugal.pt

Working Papers | Lisbon 2018 • Banco de Portugal Av. Almirante Reis, 71 | 1150-012 Lisboa • www.bportugal.pt •
Edition Economics and Research Department • ISBN (online) 978-989-678-600-7 • ISSN (online) 2182-0422

Every cloud has a silver lining: Micro-level evidence on the cleansing effects of the Portuguese financial crisis

Daniel A. Dias
Board of Governors of the Federal Reserve System and CEMAPRE

Carlos Robalo Marques
Banco de Portugal

June 12, 2018

Abstract
Using firm level data, we show that the Portuguese financial crisis had, overall, a cleansing effect on productivity. During the crisis, aggregate productivity gains, both in manufacturing and services, came from relatively higher contributions of entry and exit of firms and from reallocation of resources between surviving firms. At the micro-level, we find that the crisis reduced the probability of survival for high and low productivity firms, but hit low productivity firms disproportionately harder, in line with the cleansing hypothesis. The correlation between productivity and employment growth in manufacturing and services strengthened, but the correlation between productivity and capital growth in the service sector weakened. We attribute this result in part to structural sectoral differences, but mainly to the large negative demand and credit shocks that affected mainly the nontradable services sub-sector. We also find that the probability of exit increased disproportionately for firms operating in more financially dependent industries, but there is no evidence of a scarring effect on productivity stemming from changing credit conditions.

JEL: D24, E32, L25, O47

Keywords: Productivity, firm-level data, entry, exit, survival.

Acknowledgements: The analyses, opinions and findings of this paper represent the views of the authors, which are not necessarily those of Banco de Portugal, the Eurosystem, the Board of Governors of the Federal Reserve System or of any other person associated with the Federal Reserve System.

E-mail: daniel.dias@frb.gov; cmrmarques@bportugal.pt

1. Introduction

This paper studies the effect of the 2011-2012 Portuguese financial crisis on productivity dynamics. More specifically, we investigate whether this crisis had a cleansing effect by improving the allocation of resources in the economy from low- to high-productivity firms, or a scarring effect by exacerbating market imperfections and driving high-productivity firms out of the market.

The empirical evidence on this issue is mixed, with conclusions varying across countries and being conditional on the methods used. For instance, Foster *et al.* (2001) for the US and Casacuberta and Gandelman (2015) for the Uruguay, conclude that crises were times of productivity enhancing reallocation, while Nishimura *et al.* (2005) for Japan, Hallward-Driemeier and Rijkers (2013) for Indonesia and Eslava *et al.* (2015) for Colombia find scarring effects of recessions stemming from credit market imperfections. More recently, Foster *et al.* (2016) find that the intensity of reallocation fell rather than rose in the US during the Great recession (2007-2009) and that the reallocation that took place was less productivity-enhancing than in prior recessions.

An important limitation of these contributions, is that, due to data availability, the empirical evidence is restricted to the manufacturing sector. This sector contributes less than 20 percent to total GDP and has very distinct characteristics from the service sector, the largest sector in the economy. Thus, important differences between the two sectors regarding the impact of crises can be expected, which, in our view, preclude inferences for the total economy from being made, based on evidence from the manufacturing sector alone.

Our paper contributes to literature by bringing forward novel evidence on the consequences of financial crises on resource reallocation and productivity, involving the various sectors of the economy. Using micro-level data for the Portuguese economy, we investigate how the patterns of resource reallocation changed during the Portuguese financial crisis in terms of intensity and the extent to which it was productivity enhancing and long-lasting. Given that we have data for the whole economy, an important contribution of our paper is that it contrasts the evidence for the different sectors, namely manufacturing and service sectors. More specifically, this paper addresses the following questions: Did the patterns of resource reallocation changed during the 2011-2012 financial crisis? Was reallocation productivity enhancing and long-lasting? Were manufacturing and services differently affected? Is there evidence of a negative impact of credit constraints on productivity dynamics?

In order to answer these questions, we study the dynamics of two measures of productivity - labor productivity computed from value added and total factor productivity (TFP) computed from gross output - during the pre-crisis, crisis and recovery periods. Following the literature, we decompose productivity according to the contributions of the different types of firms (surviving, entering and exiting firms) and estimate regressions on exit, entry and input growth to evaluate the implications of the crisis on input reallocation.

Our results suggest that, in general, the 2011-2012 financial crisis in Portugal had, overall, a cleansing effect on productivity, both in manufacturing and services. At the macro level, we find higher positive contributions for productivity growth of the between-firm and exiting components, during the crisis, together with a lower negative contribution of entry. Even though the evidence regarding the contribution of the cross-firm effects is mixed, the total impact of the different components on productivity growth is clearly positive, suggesting that, overall, the crisis was productivity enhancing, both in manufacturing and services.

At the firm-level, we find that the crisis reduced the probability of survival for high and low productivity firms, but hit low productivity firms disproportionately harder, in line with the cleansing hypothesis. For the whole economy, we estimate that the cleansing effect reduced the probability of exit in 0.56 percentage points (pp) for low productivity firms and in 1.54 pp for high productivity firms. However, the protective impact of productivity increased significantly more in relative terms in manufacturing than in the service sector. In the manufacturing sector, new firms also emerge as relatively more productive during and after the crisis, in contrast with the service sector. As for reallocation of inputs, we find a strengthening of the correlation between productivity and employment growth during the crisis, but a weakening of the correlation between productivity and capital growth, during the crisis and the recovery period. Importantly, these aggregate results reflect different sectoral developments, with the manufacturing sector exhibiting significant cleansing effects regarding employment and capital reallocation, and the service sector, mainly nontradable services, exhibiting negative or scarring effects regarding capital reallocation. This sector-level heterogeneity regarding input reallocation may, in part, have to do with the structural differences between sectors of activity (different frictions and distortions, including different competition levels and different input adjustment costs) but, by and large, must reflect the impact of specific features of the Portuguese financial crisis. Nontradable services (together with the construction sector) was the most affected sector by the sharp decline in domestic demand and increase in lending restrictiveness during the Portuguese recession (and recovery) period.

We also find that the cleansing effect documented for the crisis period was, to a large extent, a short-lived phenomenon. With the exception of the contribution of exiting firms for productivity growth, possibly due to lagged effects of the crisis, the increase in productivity contributions recorded for other components during the crisis, vanished or faded away during the recovery period.

Finally, we find that the probability of exiting increased significantly for firms operating in more financially dependent industries belonging to the nontradable sub-sector, but there is no evidence of an attenuation effect, i.e., the increase in the probability of exit, during the crisis, is not correlated with productivity. In other words, we did not find evidence that the cleansing impact, regarding exiting firms, was significantly attenuated by the presence of increased credit constraints and/or credit forbearance during the crisis.

The rest of the paper is organized as follows. Section 2 briefly describes the theoretical literature on the impact of crises on productivity dynamics, and characterizes the Portuguese financial crisis. Section 3 describes the data used and explains how the most important variables were constructed. Sections 4 and 5 present and discuss the main empirical results regarding the cleansing or scarring effects of the financial crisis separating the macro- and micro-level approaches, and section 6 summarizes the main findings. Details on the definition, estimation, interpretation and aggregation of the firm-level productivity measures used in the paper, can be found in Appendices A and B, and details on the construction of firm-level real capital stock are presented in Appendix C.

2. Related literature and context

2.1. Related literature

According to Schumpeter (1939, 1942), business cycles are driven by a process of creative destruction, by which innovative, high-productivity firms drive relatively unproductive firms out of business. Theoretical models of this hypothesis assume that recessions promote a more efficient allocation of resources by cleansing out less efficient production arrangements and redirecting resources into relatively more productive uses (see Caballero and Hammour (1994) and Mortensen and Pissarides (1994)).

However, the presence of market distortions may attenuate this cleansing effect or even reverse it, so that crises may become a period of counterproductive destruction, by hampering adjustments and protracting the recovery process. Such distortions may arise from many factors. Caballero and Hammour (1996) highlight some distortions or market failures that may have disruptive effects on job creation and job destruction, such as search inefficiencies or bargaining problems in the labor market, which reduce the impact of recessions on resource reallocation. Barlevy (2002) claims that while recessions hasten the destruction of less efficient businesses, they also make more difficult the transition of workers into more productive uses (on-the-job search is procyclical). This feature gives rise to a sullying effect that works against the conventional cleansing effect. In a similar vein, Collier and Goderis (2009) argue that regulations that delay the speed of firm exit may hinder the creative destruction process, while Haltiwanger *et al.* (2008) show that distortionary labor market regulations, like employment protection legislation, by raising labor adjustment costs and reducing job turnover, may prevent an efficient reallocation of workers. In turn, Ouyang (2009) assumes that recessions affect disproportionately infant businesses, which tend to appear as unproductive in the short run, but have the potential to reveal high productivity in the long run. By destroying young firms, recessions may scar the economy, by preventing new and innovative firms from reaching their potential. This scarring effect may offset the conventional cleansing effect. Kehrig (2015) suggests a model in which the fall in factor prices during recessions increases the probability of surviving for low productivity firms and thus mitigates the cleansing effect.

Importantly, in the presence of credit market distortions, recessions may hurt efficient firms disproportionately, as they have higher financing needs. Barlevy (2003) shows that the presence of financial constraints may reverse the conventional cleansing effect, because reallocation may direct resources from more efficient to less efficient uses. In contrast, Osotimehin and Pappadà (2017) suggest a model where credit frictions reduce the intensity of the cleansing effect but do not reverse it.[1]

In short, economic theory suggests that whether recessions have a cleansing or a scarring effect on productivity depends on the type and importance of distortions prevailing in the economy. In the absence of distortions, recessions are expected to promote a more efficient allocation of resources by cleansing out less efficient firms and redirecting resources into relatively more productive uses. But, the presence of market distortions, especially in the labor and capital markets, may hinder the creative destruction process by delaying the speed of firm exit or preventing an efficient reallocation of resources.

2.2. The Portuguese financial crisis

Between 1995 and 2001 the Portuguese economy benefited from the Eurozone convergence in the run-up to the introduction of the euro, undergoing a structural transformation, shifting away from manufacturing and towards services. However, this came at the expense of lower competitiveness and higher indebtedness. By 2002, investment and GDP had stagnated, but large current account and headline budget deficits remained, resulting in general government debt breaching 60% of GDP in 2004.

The whole situation deteriorated further in the following years, also as a consequence of the 2008 international financial crisis. By 2010, the interest rates on long-term Portuguese government bonds started rising, a few months after the same had happened in Greece. By April 2011 the Portuguese government was forced to ask for external assistance. One month later, the troika comprised of the International Monetary Fund, European Commission

1. The key difference between these two models is the way they model the exit decisions of firms that are subject to credit restrictions. In the first paper, it is assumed that high productivity firms are more likely to be subject to credit restrictions and thus more likely to exit the market, while the second accounts for the role of profitability in the exiting decision of the firm, so that high productivity firms have a lower probability of falling below the net-worth exiting threshold.

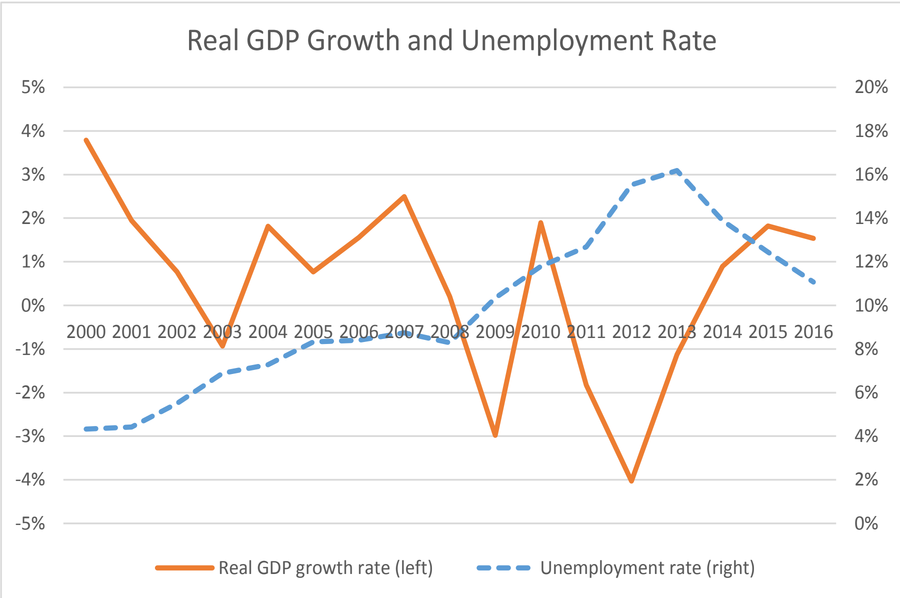

FIGURE 1: Economic growth and unemployment in Portugal

and European Central Bank approved a memorandum of understanding with the Portuguese government in exchange for a rescue package (The economic and financial assistance programme).[2] This package "guaranteed the financing of the Portuguese economy for a period that allows implementing a gradual and structural correction of the imbalances in the public finances and external accounts, in addition to preparing and implementing the structural reforms required to reverse the main structural impediments to the economy's growth potential" (Annual Report, Bank of Portugal, 2011).

Against this background, in 2011 and 2012 there were unprecedented fiscal consolidation efforts, based essentially on tax increases and a strong contraction of public expenditure (namely public sector wage bill and investment), accompanied by a significant increase in the degree of lending restrictiveness by the Portuguese banks (given the virtual absence of external market funding). As a consequence, in this period, a sharp decline in domestic demand (private consumption, public consumption and investment) was observed, GDP decreased substantially and the unemployment rate recorded a large increase (see Figure 1). Only in the second half of 2013 did the economy start to show the first signs of a recovery. Indeed, although GDP declined, in annual average terms, by -1.1 per cent in 2013, it underwent a market intra-annual recovery

2. See Blanchard (2007), Reis (2013) and Blanchard and Portugal (2017) for detailed analyses of the evolution of the Portuguese macroeconomy in the run-up to the Eurozone crisis.

that led GDP to stand, in the last quarter of the year, 1.7 percent above the level recorded in the last quarter of 2012 (Economic Bulletin, April 2014, Bank of Portugal). The unemployment rate, however, started to decline only in 2014.

Some important features of the Portuguese recession, which include the negative demand shock implied by the fiscal consolidation efforts and the increase in the degree of lending restrictiveness, are expected to have a bearing on the findings of this paper, by their potential heterogeneous impacts on firms and sectors of activity. The sharp decline in domestic demand affected differently the tradable and nontradable sectors of the economy. During this period, exports of goods and services, in contrast to the strong contraction in the rest of the economy, displayed robust growth, even above external demand, implying a significant gain in the exports market shares. On average, while domestic demand decreased around 6 percent per year in 2011 and 2012, exports increased, on average, around 5 percent per year in this period, contributing positively to GDP growth.[3] The increase in the degree of lending restrictiveness (banks were required to reduce loan-to-deposit ratios to sustainable levels) is also expected to have affected firms and sectors differently. There is evidence that the increase in bank lending restrictiveness hit the nontradable sector, including construction, real estate and trade (retail and wholesale) disproportionately hard (Annual Report, 2012, Bank of Portugal).[4]

3. The data

In this paper we use firm-level balance sheet data that draw on annual information for Portuguese firms reported under the *Informação Empresarial Simplificada* (IES), covering the period 2006 to 2015. IES data exist from 2006 onwards and covers virtually the universe of Portuguese non-financial firms. The almost universal coverage of IES emerges from the fact that it is the system through which firms report mandatory information to the

3. The positive performance of exports during the recession period, also recorded in other euro-area countries, like Ireland and Spain, has been explained in the literature by a negative relationship between domestic demand and exports: in periods of economic stress, firms are more willing to pay the sunk costs for entering a new market abroad (survival driven exports). See, for instance, Belke *et al.* (2015), Eichenbaun *et al.* (2016) and Esteves and Prades (2018).

4. Between 2011 and 2014 several labor- and product-market structural reforms were implemented in Portugal. The labor-market reforms reduced severance payments, and the duration and level of unemployment benefits, and simplified individual and collective dismissal procedures. Product-market reforms included privatizations, the simplification of licensing procedures, the phasing out of regulated tariffs on electricity and gas, increased competition in retail trade, reduced barriers to entry in professional services, etc. These reforms, however, are not expected to have had a significant impact on the findings of this paper for the crisis period (2011-2012), because most of them, namely the ones regarding the labor market, were implemented only on the second half of 2012. For further details on the structural reforms implemented see, for instance, Eichenbaun *et al.* (2016) and OECD (2017).

tax administration and the statistical authorities like the *Instituto Nacional de Estatística* (INE) (the Portuguese Statistics Institute), and the *Banco de Portugal* (the Portuguese central bank). The data provide very detailed information on the firms' balance sheets and income statements. From this dataset, we get information on firm's gross output, value added, consumption of intermediate inputs, labor costs, employment, gross fixed capital formation, capital depreciations, and the book values of the capital stock.

Before using the data, we clean the dataset by dropping firms that do not report strictly positive figures for gross output (production), labor costs, employment, capital stock, intermediate consumption and value added. After cleaning the data, we are left with a number of firms that varies between 240,030 in 2006 and 247,575 in 2015.

Table 1 records the relative importance of the main sectors of activity in our dataset (agriculture, manufacturing, construction, utilities and services) in terms of gross output (GO), gross value added (GVA) and employment (Emp). Note the small contribution of agriculture for total employment and value added (around 2 percent), while manufacturing contributes around 25 percent and the service sector around 60 percent.[5] Note also that the construction sector lost about 40 percent of its contribution to aggregate value added between 2006 and 2015, reflecting the structural crisis underwent by this sector since the early 2000's. Table 1 also distinguishes between tradable and nontradable services.[6] Tradable services contribute about 12 percent to total value added and correspond to about 20 percent of the service sector.

In order to obtain estimates for real gross output, real value added and real intermediate consumption, we use industry-level price indices. These price indices for the manufacturing sector were built with information from the disaggregate manufacturing production price index (obtained from INE). For the non-manufacturing industries, for which no price index was available, we used alternative deflators depending on the type of industry (consumer price index, investment goods deflator). In order to compute the real stock of capital, we used the perpetual inventory method, with a special adjustment factor for the first year of the sample (2006). This approach is similar to that used by Foster *et al.* (2016) and the details of the procedure can be found in Appendix C.

5. According to information from the National Accounts, in 2010, agriculture, manufacturing and services contribute 2.3, 13.8 and 73.8 percent for aggregate GDP, respectively. Thus, if anything, our dataset appears to be slightly skewed towards manufacturing and against the service sector. We note, however, that in contrast to the National Accounts, services in our dataset do not include information of the government sector, the financial sector and self-employment.

6. The distinction among tradable and nontradable industries follows Amador and Soares (2012). They define as tradable the industries for which the export to sales ratio is above 15 percent, along with all the manufacturing industries.

	2006			2010			2015		
	GO	GVA	Emp.	GO	GVA	Emp.	GO	GVA	Emp.
Agric.	2.0	2.1	2.1	2.1	1.9	2.2	2.5	2.2	2.6
Manuf.	32.9	25.6	27.9	31.5	23.1	24.0	34.8	25.1	24.4
Const.	15.0	11.5	13.2	13.9	10.3	12.4	7.6	7.0	8.7
Utilities	3.3	4.4	0.4	2.7	4.0	0.4	6.4	4.4	0.5
Services	46.8	56.4	56.3	49.9	60.6	61.0	48.6	61.4	63.8
T. serv.	10.3	10.3	8.8	11.8	12.1	9.9	12.4	13.4	10.7
NT. serv.	36.6	46.2	47.5	38.1	48.5	51.2	36.3	48.0	53.1

TABLE 1. Relative importance of each sector in the dataset (percentage)

Note: Agriculture also includes forestry, fishing, mining and quarrying; the utilities sector include electricity, gas and water services.

The dataset also includes information on the firm's main industry of operation based on NACE classification (Rev. 2.1 and Rev. 3) both at 3- and 5-digit disaggregation level. However, the exercises in our paper are conducted with industries defined at the 3-digit NACE code (Rev. 2.1), because we do not have information on prices at a higher disaggregation level, and also because the number of firms at a 5-digit classification will be very small for many industries, making it impossible to estimate the corresponding production functions. After dropping industries with less than 10 firms (to avoid estimation problems), the 3-digit NACE code classification implied 202 final different industries - 16 for agriculture (including forestry, fishing, mining and quarrying), 101 for manufacturing and 85 for services (including construction and utilities).

4. Cleansing or scarring effects of the crisis? Macro-level evidence

The literature outlined above yields competing testable predictions at both the macro- and micro-level for the cleansing or scarring effects of recessions. To test whether the Portuguese crisis had a cleansing or a scarring effect on productivity, we follow closely the approaches suggested in Hallward-Driemeier and Rijkers (2013) and Foster *et al.* (2016). In this section we investigate the macro-level or aggregate implications. The micro-level implications are investigated in the next section.

In order to investigate the macro-level implications, we decompose aggregate productivity growth into the contributions of the different groups of firms (survivors, entrants and exiters) to see whether there is evidence of a significant change in the contribution of these groups to aggregate productivity growth during and after the crisis. We start by introducing the relevant productivity decomposition.

4.1. Decomposing aggregate productivity growth

In line with the literature, we define aggregate productivity at time t as a share weighted average of firms productivity p_{it}:

$$P_t = \sum_i \theta_{it} p_{it} \tag{1}$$

where the shares $\theta_{it} \geq 0$ sum to 1. The variable of interest is the change in aggregate productivity over time $\Delta P_t = P_t - P_{t-1}$, or, more generally, $\Delta_r P_t = P_t - P_{t-r}$. Because this productivity change is measured in differences we assume that the underlying productivity measure is in logs, so that ΔP_t represents a percentage change. The literature has used different choices both for p_{it} and the share weights θ_{it}. In Appendix B, we discuss the alternatives and justify the choices used in our empirical application.

To assess whether crises have a cleansing or a scarring effect at the aggregate level, we decompose aggregate productivity growth using an extended version of the so-called Dynamic Olley-Pakes decomposition, proposed by Melitz and Polanec (2015). Let $\theta_{kt} = \sum_{i \in k} \theta_{it}$ represent the aggregate market share of a group K of firms and define $P_{kt} = \sum_{i \in k} (\theta_{it}/\theta_{kt}) p_{it}$ as the average aggregate productivity of firms in group K. Melitz and Polanec (2015) show that we can express aggregate productivity for periods 1 and 2 (for instance) as a function of the aggregate share and aggregate productivity of surviving, entering and exiting firms, where $\theta_{i1} = 0$ for entrants and $\theta_{i2} = 0$ for exiters:

$$\begin{aligned} P_1 &= \theta_{S1} P_{S1} + \theta_{X1} P_{X1} = P_{S1} + \theta_{X1}(P_{X1} - P_{S1}) \\ P_2 &= \theta_{S2} P_{S2} + \theta_{E2} P_{E2} = P_{S2} + \theta_{E2}(P_{E2} - P_{S2}) \end{aligned}$$

where S, E, and X denote the sets of surviving, entering and exiting firms, respectively. From these equations we can compute the aggregate productivity change $\Delta P = P_2 - P_1$ in terms of the contribution of each group of firms:

$$\Delta P = (P_{S2} - P_{S1}) + \theta_{E2}(P_{E2} - P_{S2}) + \theta_{X1}(P_{S1} - P_{X1}) \tag{2}$$

This decomposition features a contribution of entering firms that increases with the aggregate productivity of entrants, P_{E2}, a contribution of exiting firms that increases with lower aggregate productivity of exiters, P_{X1}, and an aggregate contribution of surviving firms that increases with the difference $P_{S2} - P_{S1}$. The contribution of surviving firms can be decomposed further, and there are several possibilities. For example, Melitz and Polanec (2015) suggest decomposing the contribution of surviving firms using the well-known Olley-Pakes decomposition (Olley and Pakes (1996)).[7] An alternative approach to

7. Applying the Olley-Pakes decomposition to the surviving firms we get:

$$\Delta P = \Delta \bar{P}_S + \Delta Cov_S + \theta_{E2}(P_{E2} - P_{S2}) + \theta_{X1}(P_{S1} - P_{X1})$$

decompose the contribution of the surviving firms, which we find more intuitive, is the one suggested by Foster *et al.* (2001). Applying the Foster *et al.* (2001) decomposition to surviving firms, the full decomposition may be written as follows:

$$\Delta P = \sum_{i \in S} \mu_{i1} \Delta p_{i2} + \sum_{i \in S} p_{i1} \Delta \mu_{i2} + \sum_{i \in S} \Delta \mu_{i2} \Delta p_{i2} + \theta_{E2}(P_{E2} - P_{S2}) + \theta_{X1}(P_{S1} - P_{X1}) \tag{3}$$

where $\mu_{it} = (\theta_{it}/\theta_{St})$, with $\sum_{i \in S} \mu_{it} = 1, t = 1, 2$. We note that this equation, keeps the expressions for the contributions of entry and exit in equation (2) unaltered. The first term in this decomposition represents the "within effect", i.e., the contribution of within-firm productivity changes of surviving or continuing firms, weighted by initial market shares. The second term represents the "between effect", i.e., the contribution of market share reallocation to productivity growth, weighted by the initial productivity level.[8] The third term represents the "cross effect" (covariance type effect). The fourth and fifth terms represent the contribution of entry (entry effect) and exiting firms (exit effect) for productivity growth, respectively.

It is important to stress that decomposition (3), as decomposition (2), has an important advantage over alternative decompositions suggested in the literature. In particular, it eliminates the biases in the measurement of entry and exit contributions (and hence also in the contribution of surviving firms), that are a feature of other decomposition methods, such as the ones suggested in Griliches and Regev (1995) and Foster *et al.* (2001)). Melitz and Polanec (2015) argue that equation (2) more accurately reflects the contributions of each group of firms in the sense that we can relate each group contribution to a specific counterfactual scenario as follows: the contribution of surviving firms is simply the aggregate productivity that would have been observed in absence of entry and exit. The contribution of entry, $\theta_{E2}(P_{E2} - P_{S2})$, is the change in aggregate productivity, ΔP, generated by adding/removing the group of entrants. Similarly the contribution of exit, $\theta_{X1}(P_{S1} - P_{X1})$, is the change

where $Cov_S = \sum_{i \in S}(\theta_{it} - \bar{\theta_S})(p_{it} - \bar{P}_S)$, and $\bar{P}_S = (1/N_s)\sum_{i \in S} p_{it}$ and $\bar{\theta}_S = 1/N_s$ denote the unweighted firm productivity mean and the mean market share among surviving firms, respectively. This equation denotes the so-called Dynamic Olley-Pakes decomposition (DOLP) as suggested in Melitz and Polanec (2015). The first two terms in the equation corresponding to the Olley-Pakes decomposition show that changes in productivity over time for surviving firms are simply given by the change in the unweighted mean, $\Delta \bar{P}_S$ and the change in "covariance" term, ΔCov_S. This provides a natural way of decomposing productivity changes into a component that captures shifts in the productivity distribution (changes in the unweighted mean) and a component that captures market share reallocations (changes in the "covariance" term). A major drawback of the Olley-Pakes decomposition, for the purpose of our analysis, is that it does not allow a clear distinction between "within" and "between" effects for the surviving firms.

8. In the original decomposition suggested in Foster *et al.* (2001) the "between effect" is written as $\sum_{i \in S}(p_{i1} - P_1)\Delta \mu_{i2}$. We note that in our case, $\sum_{i \in S} \mu_{i1} = 1$, so that the two expressions coincide.

in aggregate productivity generated by adding/removing the group of exiting firms. Thus, entrants generate positive productivity growth if and only if they have higher productivity, P_{E2}, than the surviving firms, P_{S2}, in the same time period when the entry occurs (t=2). Exiters generate positive productivity growth if and only if they have lower productivity, P_{X1}, than the remaining surviving firms, P_{S1}, in the same time period when exit occurs (t=1).[9]

Under the cleansing hypothesis, we should expect an increase in the contribution of exit and entry for productivity growth, as well as an increase in resource reallocation (relatively more productive firms gaining market share) and a stronger correlation between changes in productivity and changes in market share (firms that experience larger productivity losses suffer simultaneous reductions in market share). Thus, in terms of decomposition (3), if crises have a cleansing effect, one would expect to see a higher contribution from exit and (possibly) of entry. We should also witness an increase in the between term, and thus the relative contribution of within-firm adjustment to aggregate productivity growth to be proportionately smaller than during normal times. Increases in the cross term should also be expected.

By contrast, under the scarring hypothesis, stemming from credit market constraints, we should expect firms more dependent on credit to be more affected. During financial crises credit market distortions reduce the efficiency of resource reallocation through reduced bank lending to profitable projects that require more capital. Under these circumstances, we should witness the exit of high-productivity firms (because they are financially constrained). This would show up in a negative (or reduced) contribution of exit to productivity growth in equation (3). Banks may also forbear bad debtors delaying the process of downsizing or firm death, in order to protect their balance sheets (zombie lending or evergreening of loans), thereby hindering one of the mechanisms through which productivity growth arises. In this case, one might also not witness an increase in the between- and/or the cross-term (employment and/or capital reallocation not reacting to changes in productivity).

In order to conduct our aggregate productivity decomposition exercises, we look at two alternative productivity measures, p_{it}, to be used in equation (3): a labor productivity measure defined on value added and a total factor

9. The main distinguishing feature of Melitz and Polanec (2015) decomposition compared to Griliches and Regev (1995) and Foster *et al.* (2001) decompositions stems from the fact that they use different reference productivity levels for entrants and exiters. In Griliches and Regev (1995) both entry and exit are compared to $\bar{P} = (P_1 + P_2)/2$, while in Foster *et al.* (2001) entry and exit are compared to aggregate productivity in period 1, P_1. By contrast, in Melitz and Polanec (2015) the reference productivity levels for entrants, P_{S2}, differs from the reference productivity level for exiters, P_{X1}. Suppose, for example, that productivity is growing so that $P_{S2} > P_{S1}$. The reference productivity levels P_1 in Foster *et al.* (2001) and $\bar{P}$ in Griliches and Regev (1995) are below P_{S2}, leading to an overmeasurement of the contribution of entry for both decompositions, and hence an undermeasurement of the contribution for the two remaining groups of firms.

productivity measure (TFP) defined on gross output. More specifically, the labor productivity measure is defined as the log difference of real value added and employment (number of employees), while TFP is computed as the estimated residuals of a three input Cobb-Douglas production function defined on real gross output. The production functions are estimated at the industry level using the Levinsohn-Petrin estimator (see Levinsohn and Petrin (2003)), to account for the endogeneity of the regressors.[10] Firm-level productivity measures are aggregated at the industry, sectoral or total economy level using, as weights, the shares of log employment for labor productivity, and of log input mix for TFP.[11] This way, we account for the presence of measurement errors in the weights, which may have important implications for the estimates of aggregate productivity measures. The details on the definitions, estimation, interpretation and aggregation of our productivity measures are discussed at length in Appendices A and B.

4.2. Aggregate productivity before, during and after the crisis: contributions of between, cross, entry and exit effects.

Following the discussion above, we start by investigating the behavior of entrants, exitors and survivors assuming the decomposition in equation (3). Given the above described economic developments, we consider three distinct time sub-periods: "pre-crisis" (2006-2010), "crisis" (2011-2012) and "recovery" (2013-2015). The annual average contributions for aggregate productivity growth for these three sub-periods are recorded in Table 2.

	Labor Productivity			TFP		
Components	Pre-crisis (2006-2010)	Crisis (2011-2012)	Recovery (2013-2015)	Pre-crisis (2006-2010)	Crisis (2011-2012)	Recovery (2013-2015)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Within	1.78	-2.13	3.27	0.10	-1.08	1.61
Between	2.00	2.34	1.98	0.50	0.53	0.54
Cross	-3.22	-2.89	-3.11	-0.82	-0.87	-1.09
Net-entry	-1.20	0.16	-0.56	-1.03	0.06	0.07
Entry	-3.03	-2.61	-3.28	-1.49	-0.93	-1.19
Exit	1.84	2.77	2.72	0.46	0.99	1.26
Total	-0.64	-2.51	1.57	-1.24	-1.35	1.13

TABLE 2. Productivity decompositions (Total economy): average annual contributions

Note: Labor productivity refers to value-added per employee, with the shares of log employment as weights; TFP refers to gross-output, with the shares of log input mix as weights. Figures do not include the contribution of the utilities sector.

10. As robustness checks, we also computed TFP using OLS estimates and input shares (under the CRS assumption). The qualitative conclusions obtained in this paper for these alternative TFP measures do not depend on the estimation method used.

11. The input-mix is defined as a geometric mean of inputs using estimated factor elasticities.

Let us start by looking at the effect of entry and exit on aggregate productivity growth.[12] According to the discussion above, if the crisis has a cleansing effect we should expect a higher contribution from exit and possibly of entry, and thus an increase in the net-entry contribution. From Table 2, we can see that there is an increase in the net entry contribution during the crisis for the two productivity measures. In particular, the average annual net-entry contribution for TFP growth is negative between 2006 and 2010 (-1.03), but slightly positive (0.06 percent) for the 2011-2012 period, so that there is an average annual increase of 1.09 percentage points (pp) in the net-entry contribution to TFP growth. Similar numbers are obtained for labor productivity. In turn, the increase in net-entry contribution reflects a large increase in the positive contribution of exit, but also a significant reduction in the negative contribution of entry, suggesting that productivity of entrants increased during the crisis relatively to that of survivors. Interestingly, in the case of labor productivity the contribution of net-entry turns negative again in the recovery period, while the TFP contribution remains about the same, as in the crisis period. This difference may stem from the fact that new firms have less capital. While TFP takes this fact into account, labor productivity does not and indicates lower productivity.

We note also that the between-firm component increased during the crisis, for the two productivity measures, with a more significant impact in case of labor productivity. Thus, if anything, the evidence suggests that during the crisis relatively more productive firms, among survivors, exhibited higher input growth, as one could expect under the cleansing hypothesis. As for the cross effect, we get a significant positive change during the crisis for labor productivity (+0.33) and a small negative change for TFP (-0.05). Together, the total impact of reallocation (change in the between- and the cross-firm components) is positive for labor productivity (+0.67) and virtually null for TFP (-0.02) suggesting that the negative contribution of reallocation before the crisis may have been attenuated during the crisis. Similarly to the net-entry contribution, there is some evidence of a deterioration in the contribution of the between and cross terms during the recovery period, suggesting that the cleansing impact of the crisis was a short-lived phenomenon. Finally, we note that there is a significant decline in the contribution of the within effect during the crisis, that is followed by a strong recovery in the recovery period, as could be expected.

12. The estimates of our productivity measures for the utilities sector are very erratic, displaying huge annual variations that can be as big as +30 percent (for TFP in 2007) or -30 percent (for value-added labor productivity in 2015). In accumulated terms, between 2006 and 2015, the numbers also vary across our productivity measures beyond any sensible thresholds (+15 percent for TFP and -82 percent for value-added labor productivity) making it impossible to draw any interesting conclusions. For this reason, in what follows figures for the "Total economy" exclude the contribution of this sector.

Overall, we interpret the evidence of higher positive contributions of the between and exiting components, together with a lower negative contribution of entry, as evidence of a cleansing effect of the 2011-2012 financial crisis.

	Manufacturing			Services		
Components	Pre-crisis (2006-2010)	Crisis (2011-2012)	Recovery (2013-2015)	Before (2006-2010)	Crisis (2011-2012)	Recovery (2013-2015)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Within	2.14	-1.17	2.25	2.12	-2.64	3.87
Between	1.19	1.31	1.18	2.40	2.58	2.18
Cross	-1.66	-1.44	-1.50	-3.76	-3.42	-3.57
Net-entry	-0.04	0.67	-0.23	-1.56	-0.21	-0.89
Entry	-1.94	-1.93	-2.40	-3.39	-2.90	-3.66
Exit	1.90	2.60	2.17	1.82	2.69	2.77
Total	1.63	-0.63	1.70	-0.79	-3.69	1.59

TABLE 3. Labor productivity decomposition (manufacturing and services): average annual contributions

Note: Labor productivity refers to value-added per employee; the weights are the shares of log employment; The service sector does not include construction nor utilities (electricity, gas and water services).

	Manufacturing			Services		
Components	Pre-crisis (2006-2010)	Crisis (2011-2012)	Recovery (2013-2015)	Pre-crisis (2006-2010)	Crisis (2011-2012)	Recovery (2013-2015)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Within	0.54	-0.61	1.04	0.05	-1.10	1.81
Between	0.66	0.86	0.80	0.60	0.66	0.56
Cross	-0.83	-0.97	-1.16	-0.86	-0.92	-1.18
Net-entry	-0.22	0.35	0.85	-0.98	0.62	0.14
Entry	0.95	0.89	1.12	-2.33	-1.43	-1.92
Exit	-1.17	-0.54	-0.27	1.35	2.05	2.06
Total	0.15	-0.37	1.53	-1.19	-0.74	1.33

TABLE 4. TFP decomposition (manufacturing and services): average annual contributions

Note: TFP refers to gross-output with weights given by the shares of log input mix. The service sector does not include construction nor utilities (electricity, gas and water services)

Tables 3 and 4, which break down the contributions for productivity growth by sectors of activity, show that the cleansing effect of the crisis is present in both the manufacturing and the service sectors. The net-entry contribution and the between-firm contribution increase during the crisis (especially the former) in the two sectors and for the two productivity measures. Again, for the cross-firm contribution the evidence is somewhat mixed: it increases in both sectors in terms of labor productivity, but decreases in terms of TFP. If we put together the changes between the "pre-crisis" and the "crisis" periods, by adding up the variations in the between-firm, cross-firm and net-entry contributions to productivity growth, we conclude that they are positive both in the manufacturing and the service sectors.[13] We interpret this results as evidence of an overall cleansing impact of the crisis in both sectors. If we look further into the service sector, we also find evidence of a cleansing effect both in tradable and nontradable services.[14] In summary, the aggregate and sectoral analysis suggests that the 2011-2012 financial crisis was productivity enhancing, and that three sectors - manufacturing and the tradable and nontradable service sectors - contributed to the overall cleansing impact.

As a robustness test, we also computed the decompositions for labor productivity using employment shares as weights (some exercises carried out showed that employment is not very much affected by outliers), and for TFP using the shares of log nominal gross output as weights.[15] The decompositions are recorded in Tables A3 (aggregate economy), A4 and A5 (sectoral disaggregation) in Appendix D. The conclusions on the cleansing impact of the crisis are qualitatively similar to the ones obtained from Tables 2, 3 and 4, for both labor productivity and TFP: there is an increase in the between-firm and net-entry contributions during the crisis (reflecting an increase in the positive exit contribution and a decrease in the negative entry contribution) and the absence of a clear-cut impact of the cross-firm contribution (positive for TFP, but negative for labor productivity).[16]

13. For labor productivity the figures are 1.05 pp in manufacturing and 1.87 pp in services, while for TFP the figures are 0.63 pp and 1.60 pp, respectively.

14. The overall change between the pre-crisis and the crisis periods, involving the between-firm, cross-firm and net-entry contributions for tradable and nontradable services are as follows: a) labor productivity: 1.81 pp for tradable services and 1.93 pp for nontradable services; b) TFP: 1.06 pp for tradable services and 1.75 pp for nontradable services. See Tables A1 and A2 in Appendix D

15. See Appendix B for a discussion on the use of gross output shares as alternative weights to compute aggregate TFP.

16. For TFP, note also that the use of gross output shares as weights in Tables A3 and A5 increases the contributions of the cross effects and decreases the contributions of the between and within effects, in comparison with the use of the input-mix shares in Tables 2 and 4. For the aggregate economy, the cross-firm contributions and the between-firm contributions even reverse signs. A similar phenomenon involving the contributions for these two components may be found, for instance, in Foster *et al.* (2001), where employment and gross output shares are used as weights to compute aggregate TFP. In order to understand these results recall that the production function implies that $\Delta ln(TFP_{it}) = \Delta ln(Q_{it}) - \Delta ln(IM_{it})$, where Q_{it} and IM_{it} stand for the gross output and the input mix respectively. Thus, changes in Q_{it} stemming from shocks, other than input shocks, such as measurement errors in Q_{it}, demand shocks or other supply shocks imply, tantamount, a similar change in measured TFP, generating an upward bias in the correlation between $\Delta ln(TFP_{it})$ and $\Delta ln(Q_{it})$, and contributing to a positive cross effect, when gross output shares are used as weights. The opposite holds for shocks to inputs that have no implications on the level of output. For instance, measurement errors in the inputs, including re-evaluations or large amortizations of the capital stock, generate a downward bias

5. Cleansing or scarring effects of the crisis? Micro-level evidence

We now investigate the micro-level testable implications of the cleansing or scarring hypothesis of the crisis. Under fairly general conditions, low productivity firms are more likely to exit and more productive firms are more likely to grow (see, for instance, Jovanovic (1982), Hopenhayn (1992) and Ericson and Pakes (1995)). This reallocation of outputs and inputs from low productivity to high productivity firms is expected to contribute significantly to aggregate productivity growth.

Under the cleansing hypothesis, we should expect recessions to accelerate the exiting of low-productivity firms, resulting in a stronger association between survival and productivity. In addition, we should witness a strengthening of the correlation between productivity and employment and/or capital growth, as less productive firms should shrink more than productive firms, in response to negative shocks. Finally, an increase in the productivity of entering firms, relatively to that of incumbent firms, can also be expected. By contrast, under the scarring hypothesis, one should expect recessions to weaken these relationships, so that the link between productivity, exit, entry and input growth should be attenuated. As noted above, during financial crises credit market distortions may reduce the efficiency of resource reallocation through reduced bank lending to profitable projects that require more capital. Under these circumstances, we should witness the exit of high-productivity firms (because they are financially constrained) and an attenuation of the link between productivity and survival. In addition, banks may also forbear bad debtors delaying the process of downsizing or firm death, thereby hindering one of the mechanisms through which productivity growth arises. In this case, we might also not witness a strengthening of the correlation between productivity and input growth.

In order to examine if crises have a cleansing effect, i.e., there is a connection between recessions and productivity-enhancing reallocation at the micro level, we follow Foster *et al.* (2016) and estimate simple linear models linking survival, input growth or entry to productivity. Our empirical model is given by:

$$y_{i,t+1} = \lambda + \beta p_{it} + \delta c_t + \gamma c_t.p_{it} + \mu r_t + \theta r_t.p_{it} + \varepsilon_{it} \tag{4}$$

where the left-hand side variable, $y_{i,t+1}$ stands for a set of outcomes. It is a dummy variable in the regressions regarding exit and entry (taking the value 1 if firm i exits or enters the market in the following period and 0 otherwise), and is a quantitative variable in the regressions for input growth (employment and capital growth). The regressor c_t is a dummy variable for the crisis years, r_t is a dummy variable for the recovery period and p_{it} stands for the log of

in the correlation between $\Delta ln(TFP_{it})$ and $\Delta ln(IM_{it})$, contributing to a negative cross effect, when input shares are used as weights.

productivity. This specification is very general, as all the parameters of the model are allowed to vary over time, delivering estimates for the pre-crisis (2007-2010), crisis (2011-2012) and the recovery (2013-2015) periods.

In the case of exit, $y_{i,t+1}$ is a dummy variable equal to 1 if firm i exits the market in period (t+1). For this case, the parameter β is expected to be negative, that is, the higher the productivity the lower the risk of exiting. Under the hypothesis that the crisis has a cleansing impact, i.e., intensifies the creative destruction process, we should expect $\gamma < 0$. By contrast, if $\gamma > 0$ we conclude that the crisis had a hampering effect on the process of creative destruction. Parameter δ also has an interesting interpretation, as it allows us to evaluate the increase in the probability of exit during the crisis that is not correlated with productivity. A positive δ, together with a negative γ, has a strengthening effect on the cleansing effect, as the probability of exit of low productivity firms is disproportionately increased by a positive δ. Finally, as the process of creative destruction may take time, the parameters θ and μ allow us to investigate whether the cleansing or scarring processes were continued or hampered during the recovery period.

In order to asses if employment or capital growth became more strongly associated with productivity during the crisis, we estimate equation (4) where now y_{it} represents employment or capital growth in period t.[17] Under general conditions the parameter β is expected to be positive, that is, input growth should be increasing in productivity. Under the hypothesis that the crisis has a cleansing impact, i.e., intensifies reallocation of inputs from low productivity to high productivity firms, we should expect $\gamma > 0$. By contrast, if $\gamma < 0$ we conclude that the crisis reduced the importance of productivity as a determinant of firm growth. Again, the analysis of parameters θ and μ allow us to investigate whether the process of input reallocation stopped immediately after the crisis, or continued over the recovery period.

Similarly, to investigate whether the crisis increased the productivity of entrants relatively to that of incumbent firms, we estimate a variant of equation (4) that relates the probability of firm entry to productivity, i.e., where y_{it} is a dummy variable which equals 1 if firm i is an entrant, and is zero otherwise. Finally, to uncover potential scarring effects of the crisis associated with changing credit conditions, we estimate a generalization of equation (4) that additionally includes an industry-level indicator of financial dependence, and that also distinguishes between crisis and non-crisis periods.

In this section, we restrict the analysis to TFP as our measure of productivity. We believe that TFP is a better measure of productivity than labor productivity, because it takes into account usage of all factors of production. At the same time, this concept of productivity is likely to be the one

17. As timing is important, we note that in the models we explore the determinants of exit and input growth from t to t+1 based on firm level productivity in period t.

closest to the concept of productivity that firm managers consider for decision making.

5.1. Exit

The estimation results for exiting firms are in Tables 5-8. Tables 5 and 6 also include the estimation results regarding input growth that we comment in the next subsection.

Covariates	Exit	Empl. growth (Survivors + exiters)	Empl. growth (Survivors only)	Capital growth (Survivors + exiters)	Capital growth (Survivors only)
(1)	(2)	(3)	(4)	(5)	(6)
constant	0.16766 (72.58)***	−0.17518 (−58.59)***	−0.15920 (−48.69)***	−0.15349 (−27.17)***	−0.11024 (−18.31)***
p_{it}	−0.02214 (−41.00)***	0.04333 (61.03)***	0.04256 (55.27)***	0.05889 (43.95)***	0.05375 (37.33)***
c_t	0.02637 (18.57)***	−0.04578 (−26.31)***	−0.04314 (−25.23)***	−0.09539 (−30.87)***	−0.08058 (−28.47)***
$c_t.p_{it}$	−0.00215 (−6.94)***	0.00134 (3.44)***	0.00088 (2.32)**	−0.00124 (−1.77)*	−0.00274 (−4.22)***
r_t	0.01917 (13.69)***	−0.00265 (−1.74)*	−0.01594 (−9.38)***	−0.06187 (−21.94)***	−0.06265 (−21.60)***
$r_t.p_{it}$	−0.00180 (−5.81)***	−0.00040 (−1.18)	−0.00003 (−0.08)	−0.00216 (−3.38)***	−0.00286 (−4.33)***
Observations	1,821,361	2,044,591	1,672,489	2,044,591	1,672,489
Industry FE	Yes	Yes	Yes	Yes	Yes

Table 5. Reallocation and TFP (Total economy)

Note: Exit, employment and capital growth are measured from period t to period t+1. Regression for exit is a linear probability model where exit=1 if the firm is in the dataset in period t but not in period t+1; p_{it} stands for log firm-level TFP; c_t is a dummy variable equal to one for years 2011-2012 and r_{it} is a dummy variable equal to one for years 2013-2015. T-statistics (in parentheses) are obtained using standard errors clustered by industry; $^{***}p < 0.01$, $^{**} < 0.05$, and $^{*}p < 0.10$.

We start by focusing on exiting firms for the aggregate economy (Table 5, second column). Under the cleansing hypothesis, recessions are expected to accelerate the exiting of low-productivity firms, resulting in a stronger association between survival and productivity at the micro-level. From Table 5 we see that the coefficient associated with the log of productivity (p_{it}) is negative, which means that productivity has a protective impact on firms, increasing their probability of survival: one percent increase in TFP reduces the probability of exiting by 2.21 percent. Of primary interest, we also find that the relationship between productivity and firm survival is enhanced during the crisis (the interaction effect is negative and significant): the negative impact

Sectors	Exit	Empl. growth (Survivors + exiters)	Empl. growth (Survivors only)	Capital growth (Survivors + exiters)	Capital growth (Survivors only)
(1)	(2)	(3)	(4)	(5)	(6)
Manufacturing:					
p_{it}	−0.00897	0.03313	0.03231	0.04856	0.04440
	(−7.48)***	(17.91)***	(16.48)***	(16.57)***	(14.75)***
c_t	0.02170	−0.04599	−0.04299	−0.08145	−0.07407
	(7.56)***	(−12.20)***	(−12.14)***	(−14.12)***	(14.75)***
$c_t.p_{it}$	−0.00329	0.00459	0.00323	0.00194	0.00152
	(−5.22)***	(5.53)***	(4.19)***	(1.47)	(1.30)
r_t	0.01341	0.00676	−0.00955	−0.04645	−0.05509
	(4.82)***	(2.02)**	(−2.69)***	(−8.85)***	(−10.39)***
$r_t.p_{it}$	−0.00356	0.00252	0.00272	0.00315	0.00363
	(−5.93)***	(3.41)***	(3.49)***	(2.67)***	(3.08)***
Trad. services:					
p_{it}	−0.02961	0.05189	0.05360	0.04590	0.03993
	(−20.71)***	(27.75)***	(26.27)***	(12.21)***	(10.18)***
c_t	0.02348	−0.03326	−0.03036	−0.12216	−0.10255
	(6.56)***	(−8.83)***	(−6.35)***	(−12.31)***	(−10.97)***
$c_t.p_{it}$	−0.00254	−0.00003	−0.00069	−0.00022	−0.00342
	(−3.18)***	(−0.03)	(−0.63)	(−0.10)	(−1.61)
r_t	0.01232	0.00400	−0.00717	−0.07147	−0.07206
	(3.39)***	(0.94)	(−1.51)	(−7.85)***	(−7.70)***
$r_t.p_{it}$	0.00010	−0.00284	−0.00205	−0.00532	−0.00707
	(0.12)	(−2.90)***	(−1.88)*	(−2.57)**	(−3.35)***
Non T. services:					
p_{it}	−0.02981	0.04239	0.03981	0.07020	0.06401
	(−41.99)***	(48.72)***	(41.47)***	(39.44)***	(33.16)***
c_t	0.02692	−0.04352	−0.04161	−0.08741	−0.07259
	(14.32)***	(−19.87)***	(−19.00)***	(−22.19)***	(−20.05)***
$c_t.p_{it}$	−0.00204	0.00172	0.00141	−0.00176	−0.00328
	(−4.98)***	(3.58)***	(2.94)***	(−1.98)**	(−3.95)***
r_t	0.01938	−0.00285	−0.01555	−0.05815	−0.05631
	(10.42)***	(−1.50)	(−7.17)***	(−16.11)***	(−15.18)***
$r_t.p_{it}$	−0.00102	−0.00081	−0.00018	−0.00351	−0.00410
	(−2.55)**	(−1.93)*	(−0.38)	(−4.28)***	(−4.82)***
Observations	1,821,361	2,044,591	1,672,489	2,044,591	1,672,489
Industry FE	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes
Crisis FE	Yes	Yes	Yes	Yes	Yes

Table 6. Reallocation and TFP (sectors of activity)

Note: Exit, employment and capital growth are measured from period t to period t+1. Regression for exit is a linear probability model where exit=1 if the firm is in the dataset in period t but not in period t+1; p_{it} stands for log firm-level TFP; c_t is a dummy variable equal to one for years 2011-2012 and r_{it} is a dummy variable equal to one for years 2013-2015. T-statistics (in parentheses) are obtained using standard errors clustered by industry; $^{***}p < 0.01$, $^{**} < 0.05$, and $^{*}p < 0.10$.

of productivity on exit increased 0.22 percent in magnitude, which means that one percent increase in TFP reduces the probability of exit by 2.43 percent during the crisis, i.e., around 10 percent higher than in normal times. The coefficient of the crisis dummy variable, (c_t), is also positive and statistically different from zero, so that during the crisis there was an increase of 2.64 percent in the probability of exit, independent of productivity levels. This result combined with the negative coefficient of the interaction term implies a significant cleansing effect, because the probability of exit of low productivity firms is disproportionately increased during the crisis. This cleansing effect is still present in the recovery period (the coefficient of $r_t.p_{it}$ is negative and statistically significant), even though not as strongly as in the crisis period, suggesting that, at best, only part of the effect of the crisis on firm selection by productivity was permanent. This finding is fully consistent with the increase in the contribution of exit for productivity growth documented in section 4 (but we are not estimating weighted regressions, the conclusions from the models estimated in this section need not be fully in line with the evidence on the contributions from the previous section).[18]

An interesting question is whether there are significant differences across sectors regarding the impact of the crisis on exit. To investigate this issue we estimated equation (4) by sectors of activity. The results are presented in Table 6, column (2), for manufacturing, tradable services and nontradable services. A first noticeable result is that the importance of protective role of TFP (coefficient of p_{it})) is about the same in the two service sub-sectors (tradable and nontradable services) and three times as larger in these two sub-sectors compared to the manufacturing sector. A second important result is that there is a significant cleansing effect of the crisis in the three sectors, but the protective effect of TFP increased significantly more in relative terms in the manufacturing sector than in the two service subsectors: the negative impact of productivity on exit increased about 37 percent in manufacturing (about 0.33 pp), compared to between 7 and 9 percent in the nontradable and tradable services, respectively.

Using the models in column (2) of Tables 5 and 6, we can compute the changes in the probability of exit for different types of firms. Table 7 records

18. Given the well-known difficulty in obtaining accurate measures of productivity during crises periods, an obvious question is whether the results presented above are dependent on some influent observations or outliers in the data. Thus, as a robustness test we also estimated a model where productivity is ranked by terciles. The idea is that the resulting rank is immune to outliers and measurement errors in productivity. In particular, being ordinal, the rank protects against the impact of measurement errors that are common to all firms in an industry, such as using inappropriate deflators. The results of the estimated model are qualitatively similar to the ones in column (2) of Table 5. In particular they show that *i)* the probability of exit is negatively correlated with TFP: firms in the first tercile have a significantly higher probability of exiting than firms in the second and third terciles and *ii)* all firms are more likely to exit during the crisis, but firms in the lowest productivity tercile suffered the largest increase in the probability of exit (2.53 pp compared to 0.76 pp in the second tercile and 0.48 pp in the third tercile). Thus, this alternative regression corroborates the above result that the crisis reduced the probability of survival of high and low productivity firms, but hit low productivity firms disproportionately harder, in line with the cleansing hypothesis. The full set of results is available upon request.

	Average firm	Low productivity firm	High productivity firm
(1)	(2)	(3)	(4)
Manufacturing	0.77	1.41	0.12
T Services	1.29	1.64	0.93
NT services	1.85	2.19	1.51
Total Economy	1.74	2.08	1.40

TABLE 7. Changes in the probability of exit during the crisis

Note: Change in the probability of exit (percentage points) during the crisis period (2011-2012) vis-à-vis the pre-crisis period (2006-2010). Figures are computed from models estimated in Tables 5 and 6. The average firm is a firm with TFP equal to the corresponding sectoral mean. A low (high) productivity firm is a firm with productivity 1 standard deviation (s.d.) below (above) this mean.

the change in the probability of exit during the crisis for an average firm, a low productivity firm and a high productivity firm operating in each of the three sectors of activity.[19] Two interesting conclusions emerge. First, the increase in the probability of exit during the crisis is clearly lower in the tradable sector (manufacturing and tradable services) in line with the idea that this two sectors performed better than the nontradable sector during the crisis. Second, the increase in the probability of exit is clearly smaller for high productivity firms in the three sectors, highlighting again the idea that the cleansing effect was present in all sectors of the economy.[20] But we can characterize this cleansing effect even further. Table 8 shows the impact on the probability of exit associated with the cleansing effect for the different types of firms.[21] We see that, for the overall economy, the presence of a cleansing effect during the crisis reduced the probability of exit by 1.54 p.p. for high productivity firms and by 0.56 p.p for low productivity firms. The corresponding figures for the manufacturing sector are 2.05 p.p and 0.76 p.p., respectively, confirming that this sector witnessed the highest cleansing impact regarding exiting firms.

19. The average firm is defined as the firm with TFP equal to the corresponding sectoral mean. A low (high) productivity firm is a firm with productivity 1 standard deviation (s.d.) below (above) this mean.

20. Note that in the context of our estimated models, the absence of a cleansing effect would imply that the change in the probability of exit would be the same for low and high productivity firms in the sector.

21. Figures in Table 8 are obtained as the difference in the probability of exit with and without the coefficient of $c_t.p_{it}$ set equal to zero.

	Average firm	Low productivity firm	High productivity firm
(1)	(2)	(3)	(4)
Manufacturing	-1.40	-0.76	-2.05
T Services	-1.06	-0.71	-1.42
NT services	-0.84	-0.50	-1.18
Total Economy	-0.90	-0.56	-1.54

TABLE 8. Changes in the probability of exit due to the cleansing effect

Note: Differences in the probability of exit (percentage points) during the crisis period (2011-2012) vis-à-vis the pre-crisis period (2006-2010). Figures are computed from models estimated in Tables 5 and 6 with and without the coefficient of $c_t.p_{it}$ set equal to zero. The average firm is a firm with TFP equal to the corresponding sectoral mean. A low (high) productivity firm is a firm with productivity 1 standard deviation (s.d.) below (above) this mean.

5.2. Reallocation of inputs

We now look at the relationships between productivity and input (employment and capital) growth. Under the cleansing hypothesis, the correlation between productivity and employment and capital growth should strengthen, as low productivity firms should shrink more than high productivity firms, in response to negative shocks. By contrast, under the scarring hypothesis, recessions are expected to weaken those relationships, so that the link between productivity and employment and/or productivity and capital growth should be attenuated. The results of the estimated models are in Tables 5 and 6 (columns (3) to (6)). Regressions for overall input growth (survivors+exit) and conditional growth (conditional on survival that is survivors or continuers) are considered, so that the possibility of the results for input growth being driven by the exit margin is taken into account.

Table 5 shows that TFP has a positive and significant impact on employment and capital growth, irrespective of whether one looks at overall growth or survival growth, and, from Table 6, we conclude that this strong positive impact is common to the manufacturing and the two service sub-sectors. Table 5 also shows that, for the overall economy, there is a strengthening of the correlation between TFP and employment growth during the crisis (the coefficient of $c_t.p_{it}$ is positive and significant), that is, the positive impact of productivity on employment growth increased during the crisis. In contrast, the positive impact of capital growth decreases, i.e., there is an attenuation of the correlation between TFP and capital growth, during the crisis.

From Table 6, however, we conclude that the cleansing effects regarding employment are particularly strong in manufacturing (also significant, but smaller in the nontradable services and not significant at all in tradable services). The sector-level results regarding capital reallocation are also very interesting, as they show that the overall scarring effect of the crisis, recorded in Table 5, stems almost exclusively from the nontradable services sub-sector (for the other two sub-sectors, there is a non-significant weakening of the relationship in the tradable services and a non-significant cleansing effect in the manufacturing sector).[22] Comparing the evolution of the relationship from the the crisis to the recovery period allows a very interesting conclusion: in the manufacturing sector the small and non significant cleansing effect during the crisis increases and becomes significant during the recovery period, while the small scarring effect in the service sector during the crisis (but larger in the nontradable sector) also increases and becomes significant during the recovery period. Thus, manufacturing emerges as the single sector with evidence of productivity enhancing reallocation regarding both employment and capital, during the crisis and recovery periods. To put it slightly different, while in the manufacturing sector productivity increased its importance as a determinant of firm input growth (both labor and capital), during the crisis and recovery periods, mainly the opposite happened in the service sector.

We believe that some specific features of the Portuguese crisis, together with structural differences between the sectors (different frictions or distortions, including different competition levels and different input adjustment costs) underlie the sector-level heterogeneity regarding labor and capital reallocation, documented in this section. In particular, the significant weakening of the relationship between productivity and capital growth (and to a less extent between productivity and labor) in the nontradable services sub-sector, in contrast with the manufacturing sector, must reflect the fact that nontradable services (together with the construction sector) as shown in Section 2.2 were most affected by the sharp decline in domestic demand and significant increase in the degree of lending restrictiveness during the Portuguese recession period.

5.3. Entry

We now look at firm entry and investigate how the average productivity of new firms behaved during and after the crisis relative to the pre-crisis period. For that purpose, we estimate the simple linear probability model given by equation (4) for new firms, i.e., where the dependent variable is a dummy variable which equals 1 if the firm is an entrant and zero otherwise. Table 9 summarizes the results for the aggregate economy and the three main sectors of activity.

A first important conclusion is that higher productivity firms are less likely to be entrants. The estimated effect is statistically significant and relatively large. This result is common to the three sectors of activity, even though somewhat stronger in the two service sub-sectors compared to the

22. Note that the total economy considered in Table 5, besides the three sectors considered in Table 6, also includes agriculture and construction. Thus, in rigor, the aggregate scarring effect of the crisis on capital reallocation in Table 5 also reflects developments in these two sectors.

Covariates	Total Economy	Manuf.	Tradable services	Nontradable services
(1)	(2)	(3)	(4)	(5)
constant	0.26881 (135.08)***	0.20175 (40.85)***	0.28125 (53.27)***	0.29584 (111.64)***
p_{it}	−0.05221 (−113.50)***	−0.03853 (−34.10)***	−0.05455 (−44.71)***	−0.05908 (−95.29)***
c_t	−0.00595 (−6.20)***	−0.00495 (−2.65)***	−0.00912 (−3.69)***	−0.00554 (−4.33)***
$c_t{\cdot}p_{it}$	−0.00032 (−1.52)	0.00068 (1.62)	−0.00154 (−2.61)***	0.00020 (0.74)
r_t	0.00279 (3.13)***	0.00106 (0.62)	−0.00435 (−1.92)*	0.00577 (4.85)***
$r_t{\cdot}p_{it}$	−0.00053 (−2.79)***	0.00103 (2.78)***	−0.00203 (−3.83)***	−0.00022 (−0.88)
Observations	2,517,169	341,835	404,709	1,400,902
Industry FE	Yes	Yes	Yes	Yes

TABLE 9. Entry during the crisis and TFP

Note: Regression for entry is a linear probability model where entry=1 if the firm is in the dataset in period t+1 but not in period t; p_{it} stands for log firm-level TFP; c_t is a dummy variable equal to one for years 2011-2012 and r_{it} is a dummy variable equal to one for years 2013-2015. T-statistics (in parentheses) obtained using standard errors clustered by industries;$^{***}p < 0.01$, $^{**} < 0.05$, and $^{*}p < 0.10$.

manufacturing sector. Thus, entrants have, on average, lower productivity than incumbents, especially in the service sector. These findings are in line with the negative contribution of entrants documented in the previous sub-section.[23]

There is also evidence of a significant decline in the probability of a firm being an entrant during the crisis (the coefficient of c_t is negative), on the aggregate and each of the three sectors of activity, as could be expected. In terms of the interaction between TFP and the crisis and recovery dummies, at the aggregate level (column 2), we do not find evidence of a significant change in entrants productivity relative to that of survivors during the crisis, but there seems to be a small deterioration during the recovery period. However, the disaggregation by sectors of activity uncovers an important contrast between the manufacturing sector on the one side and the two service sub-sectors on the other: in the manufacturing sector, entrants during the recovery period (less so during the crisis period) were relatively more productive than before the crisis, in contrast with the service sub-sectors, where entrants either emerge as less productive during and after the crisis (tradable services) or do not exhibit a significant change (nontradable services). In summary, according to Table 9 there seems to be no significant evidence that entrants during the crisis or the

23. Note, however, that this pattern may reflect lower prices for new firms compared to incumbents, as discussed in Appendix A.

recovery period are more productive than in the pre-crisis period, except in the manufacturing sector.[24]

5.4. Financial dependence and firm dynamics

During financial crises credit market distortions may reduce the efficiency of resource reallocation through reduced bank lending to profitable projects that require more capital. Under these circumstances, high-productivity firms may exit because they are financially constrained. Bank forbearance is another channel through which credit market restrictions may distort resource reallocation, especially if banks are tempted to fund low productivity firms, so that they look artificially solvent (zombie lending). This way banks can avoid reporting loan losses in their balance sheets. If these effects prevailed in the economy, we should witness an attenuation of the link between productivity and survival due to the exit of high productivity firms in the first case, or reduced exit of low productivity firms in the second case.

Our empirical evidence so far suggests that, on average, the Portuguese crisis was productivity enhancing as we found no evidence of an aggregate attenuation effect regarding exit. However, this finding does not preclude the possibility of there being a significant number of firms that exit the market because they are not able to access credit during the crisis or firms that do not exit because of bank forbearance. In fact, in the previous subsection we found evidence of an attenuation of the correlation between productivity and capital growth, as well as an increase in the probability of exit of high productivity firms suggesting that the impact of credit constraints may have increased during the crisis. Thus, it is natural to ask whether the cleansing effect, documented above for exiting firms, would have been higher in the absence of increased credit constraints or credit forbearance during the crisis.

To answer this question, we investigate whether there is evidence of a higher probability of exit in industries where firms display higher external financial needs, and whether this probability has increased during and/or after the crisis.

We measure financial dependence at the industry level following the approach in Rajan and Zingales (1998). Data on firm's external financing (short term and long term banking debts) is available in our database. However, these data are not usable as they are expected to reflect the equilibrium between the demand for external funds and its supply. Since the latter is exactly what we are trying to test for, this information is contaminated. The approach in Rajan and Zingales (1998) assumes that there is a technological reason why some industries

24. At first sight, this finding does not seem fully compatible with the evidence in the previous section, where we found a cleansing effect of entrants during the crisis. One must note, however, that the contributions in Table 4 are weighted averages, while the estimates in Table 9 are obtained from non-weighted regressions. The combined evidence in Tables 4 and 9 thus suggests that, during the crisis, the most productive firms, among entrants, were also the largest ones.

depend more on external finance than others (for example, because initial project scale, the gestation period, the requirement to continue investing etc., differ significantly between industries). In measuring external finance, we are interested in the amount of desired investment that cannot be financed through internal cash flows generated by the same business. Therefore, we define the financial dependence indicator as the capital expenditures minus the cash flow from operations divided by capital expenditures. To avoid simultaneity issues, we compute the indicator using data for 2006 and 2007 (pre-crisis years).[25]

The estimated model, which is a generalization of equation (4), may be written as:

$$\begin{aligned} y_{i,t+1} =& \lambda + \beta p_{it} + \delta c_t + \gamma c_t.p_{it} + \mu r_t + \theta r_t.p_{it} \\ &+ \rho_1 c_t.f_{st} + \rho_2 r_t.f_{st} + \rho_3 f_{st}.p_{it} + \rho_4 c_t.f_{st}.p_{it} + \rho_5 r_t.f_{st}.p_{it} + \varepsilon_{it} \end{aligned} \quad (5)$$

where f_{st} stands for the industry-level financial dependence indicator and the other covariates are defined as above. The coefficients ρ_i (i=1,..4) capture the impact of the financial dependence indicator on the probability of exit. In particular, ρ_4, if positive, signals the presence of scarring effects of the crisis stemming from changing credit conditions.[26]

The estimated models, recorded in Table 10, show a strong contrast between the tradable and the nontradable sectors of the economy. The probability of exit during the crisis increase for firms operating in industries with higher financial dependence that belong to the nontradable sector (the coefficient of $c_t.f_{st}$ is positive), but not for firms operating in industries that belong to the tradable sector (manufacturing and tradable services). For firms of the nontradable sector, there is also evidence that, for a given level of productivity, the probability of exit increases with the degree of financial dependence (the coefficient of $f_{st}.p_{it}$ is positive and significantly different from zero) but, again, this is not the case of the tradable sector, where this coefficient even turns negative. Finally, and more importantly, there is no evidence of a crisis scarring effect stemming from the presence of financial dependence. The coefficient of

25. Time-invariant measures of external dependence at the industry level are arguably exogenous to the performance of individual firms over time, which is the source of variation in our regression.

26. Equation (5) is consistent with a theoretical model where firms facing credit constraints maximize profits in a monopolistic competitive environment (see Eslava *et al.* (2015)). Differently from Eslava *et al.* (2015)), however, who use an explicit measure of firm-level credit barriers, we use the interaction terms $f_{st}.p_{it}$ to account for the possibility of firms being heterogeneous in their access to credit within industries. For a given level of industry financial needs, firms with higher TFP are expected to face less strict barriers in accessing credit. We note also that, to the extent that our TFP measure is a revenue and not a quantity productivity measure, our model implicitly accounts for idiosyncratic demand shocks and idiosyncratic distortions that may affect the probability of exit on dimensions other than credit. See the discussion on quantity versus revenue productivity in Appendix A.

Covariates	Total Economy	Manufact.	Tradable Services	Nontradable Services
(1)	(2)	(3)		
constant	0.16870 (73.35)***	0.10694 (20.55)***	0.19365 (30.79)***	0.20422 (66.96)***
p_{it}	−0.02177 (−39.58)***	−0.01163 (−7.55)***	−0.03289 (−42.15)***	−0.02993 (−39.58)***
c_t	0.02614 (18.41)***	0.02292 (6.33)***	0.02368 (5.68)***	0.02559 (13.61)***
$c_t.p_{it}$	−0.00189 (−5.91)***	−0.00268 (−3.15)***	−0.00282 (−2.76)***	−0.00157 (−3.83)***
r_t	0.01903 (13.50)***	0.01212 (3.37)***	0.01027 (2.47)**	0.01947 (10.47)***
$r_t.p_{it}$	−0.00171 (−5.52)***	−0.00284 (−3.38)***	0.00054 (0.53)	−0.00101 (−2.46)**
$c_t.f_{st}$	0.00488 (2.57)**	0.00595 (1.07)	−0.00083 (−0.24)	0.01191 (4.07)***
$r_t.f_{st}$	−0.00084 (−0.44)	−0.00228 (−0.40)	−0.00316 (−0.92)	−0.00111 (−0.37)
$f_{st}.p_{it}$	0.00426 (5.13)***	−0.00835 (−3.05)***	−0.00701 (−3.54)***	0.00878 (8.13)***
$c_t.f_{st}.p_{it}$	0.00040 (0.93)	0.00165 (1.11)	−0.00039 (−0.45)	−0.00105 (−1.64)
$r_t.f_{st}.p_{it}$	0.00060 (1.40)	0.00193 (1.29)	0.00067 (0.79)	0.00068 (1.03)
Observations	1,821,361	255,099	292,813	1,005,992
Industry FE	Yes	Yes	Yes	Yes

TABLE 10. Firm exit, TFP and financial dependence

Note: Regression for exit is a linear probability model where exit=1 if the firm is in the dataset in period t but not in period t+1; p_{it} stands for log firm-level TFP and f_{st} for the industry-level financial dependence indicator; c_t is a dummy variable equal to one for years 2011-2012 and r_{it} is a dummy variable equal to one for years 2013-2015. T-statistics (in parentheses) obtained using standard errors clustered by industries; $^{***}p < 0.01$, $^{**} < 0.05$, and $^{*}p < 0.10$.

$c_t.f_{st}.p_{it}$ is not significantly different from zero for any of the three sub-sectors considered, which means that the probability of exit in financially dependent industries is not more (positively) correlated with TFP during the crisis than it was in the pre-crisis period. A similar conclusion holds for the recovery period. Thus, we do not find evidence that the cleansing effect detected in our baseline regressions, regarding exiting firms, would have been significantly higher in the absence of increased credit constraints or credit forbearance during the crisis.[27]

27. Recently, Blattner *et al.* (2017) investigate the implications of the regulatory intervention by the European Banking Authority on Portuguese banks in 2011. This intervention increased capital requirements for a subset of banks and the authors conclude that exposed banks cut back on credit to all but a subset of financially distressed firms for which banks had been underreporting incurred loan losses. Using the Petrin and Levinsohn (2012) decomposition the authors estimate that credit reallocation accounts for close to 20 percent of the decline in productivity in 2012. We note, that the finding in Blattner *et al.* (2017) is not necessarily inconsistent with the conclusions of this subsection, because we investigate the probability of exit in financially dependent industries during the crisis, while Blattner *et al.* (2017) investigate

The evidence in this sub-section is also relevant it that it corroborates the idea of a stark contrast between the tradable and nontradable sectors, in line with the evidence in the previous sub-sections. The absence of a significant scarring effect of credit restrictions on exiting firms, documented here, implies that credit restrictions, to the extend that they underlie the negative capital reallocation documented in sub-section 5.2, must have affected mainly surviving firms of the nontradable services sub-sector.

6. Conclusions

Whether crises have a cleansing or a scarring impact on productivity is important for economic policy. If crises are cleansing, policies aimed at containing short-term negative impacts may obstruct long-run recovery and thus be counterproductive. But, if crises are scarring, policies that mitigate short-term impacts may contribute to maximize long-term efficiency. Economic theory suggests that whether recessions have a cleansing or a scarring effect on productivity depends on the type and importance of distortions prevailing in the economy. But, the impact of recessions on resource reallocation and productivity is also expected to vary with the type of shocks hitting the economy, as these may have different firm- and industry-level implications.

One limitation of previous studies is that, due to data-availability, they are restricted to the manufacturing sector. However, manufacturing contributes less than 20 percent to total GDP and has very different characteristics from the service sector, the largest sector of the economy, which precludes generalizations to the rest of the economy. This paper adds to the literature by bringing forward novel evidence on the consequences of crises on resource reallocation and productivity, involving the various sectors of the economy.

Using micro-level data for the Portuguese economy, we investigate how the patterns of resource reallocation changed during the Portuguese financial crisis (2011-2012), in particular, the extent to which they were productivity enhancing and long-lasting. With this purpose in mind, we decompose aggregate productivity measures according to the contributions of the different groups of firms (surviving, entering and exiting firms) and estimate regressions on exit, entry and input growth, by sectors of activity (manufacturing, tradable and nontradable services).

We find that the financial crisis in Portugal had an overall cleansing effect on productivity, both in manufacturing and services, but there were significant differences regarding the impact on the patterns of resource

the impact of reduced credit on output/productivity of surviving firms. For these firms, as we have seen above, there is evidence of scarring effects regarding capital reallocation and, moreover, a significant decrease in the contribution to productivity growth took place during the crisis.

reallocation in the two sectors. This conclusion follows from the aggregate productivity decompositions performed both for labor productivity and TFP, as well as from the firm-level regressions estimated for TFP. From the aggregate productivity decompositions, we find higher positive contributions for productivity growth of the between-firm and exiting components, together with a lower negative contribution of entry, with an overall positive impact on productivity growth. From firm-level regressions on TFP, we find that the crisis reduced the probability of survival for high and low productivity firms, but hit low productivity firms disproportionately harder, in line with the cleansing hypothesis. However, the protective impact of productivity increased significantly more in relative terms in manufacturing than in the service sector. In the manufacturing sector, new firms also emerge as relatively more productive during and after the crisis, in contrast with the service sector.

From firm level regressions, we also find that more productive firms are more likely to grow, but the crisis impacted the reallocation of labor and capital differently: the correlation between productivity and employment growth strengthened, but the correlation between productivity and capital growth weakened. However, these aggregate results reflect very different sectoral developments, with the manufacturing sector exhibiting cleansing effects for both employment and capital reallocation (especially the former), and the service sector, especially nontradable services, exhibiting a significant weakening of the correlation between productivity and capital changes.

Importantly, the cleansing effect documented for the crisis period was, by and large, a short-lived phenomenon. With the exception of the contribution for productivity growth of exiting firms, possibly due to lagged effects of the crisis, the increase in productivity contributions recorded for other components during the crisis, vanished or faded away during the recovery period.

Finally, we find that the probability of exiting increased for firms operating in more financially dependent industries that belong to the nontradable services sub-sector, but there is no significant evidence of an attenuation effect, i.e., the increase in the probability of exit, during the crisis, is not correlated with productivity. In other words, we did not find evidence that the cleansing impact, regarding exiting firms, would have been higher in the absence of increased credit constraints or credit forbearance during the crisis.

Our analysis is mostly descriptive - evaluating how the patterns of resource reallocation changed over the 2011-2012 Portuguese financial crisis. In particular, this paper does not explicitly addresses why changes in reallocation patterns differed across sectors of activity. We believe, however, that a significant part of the explanation for the sector-level heterogeneity regarding input reallocation and productivity growth, documented in this paper, besides possible structural sectoral differences (different frictions or distortions, including different competition levels and different input adjustment costs), is to be found on specific features of the Portuguese crisis. In particular, the significant weakening of the relationship between productivity and capital growth, documented for the nontradable services sub-sector, in contrast with the manufacturing sector, must reflect the fact that nontradable services (together with the construction sector) were most affected by the sharp decline in domestic demand and increase in lending restrictiveness during the Portuguese crisis. But to provide more convincing evidence on the reasons behind this sector-level heterogeneity, we would need to find ways to integrate direct measures of the demand and credit shocks at the firm or at least sectoral level into the type of analysis we have conducted here.

References

Amador, João and Ana Cristina Soares (2012). "Competition in the Portuguese Economy: An overview of classical indicators." Working Paper 8, Banco de Portugal.

Baily, M., C. Hulten, and D. Campnell (1992). "Productivity Dynamics in Manufacturing Plants." *Brookings Papers on Economic Activity: Microeconomics*, 4, 187 – 267.

Barlevy, Gadi (2002). "The Sullying Effect of Recessions." *The Review of Economic Studies*, 69(1), 65–96.

Barlevy, Gadi (2003). "Credit market frictions and the allocation of resources over the business cycle." *Journal of Monetary Economics*, 50(8), 1795 – 1818.

Bartelsman, Eric and Phoebus J. Dhrymes (1998). "Productivity Dynamics: U.S. Manufactruing Plants, 1972-1986." *Journal of Productivity Analysis*, 9, 5–34.

Belke, Ansgar, Anne Oeking, and Ralph Setzer (2015). "Domestic demand, capacity constraints and exporting dynamics: Empirical evidence for vulnerable euro area countries." *Economic Modelling*, 48, 315–325.

Blanchard, Olivier (2007). "Adjustment within the euro. The difficult case of Portugal." *Portuguese Economic Journal*, 6(1), 1–21.

Blanchard, Olivier and Pedro Portugal (2017). "Boom, Slump, Sudden Stops, Recover, and Policy Options. Portugal and the Euro." Working Papers 11-2017, Banco de Portugal.

Blattner, Laura, Luisa Farinha, and Francisca Rebelo (2017). "When losses turn into loans: The cost of undercapitalized banks." mimeo.

Caballero, Ricardo J. and Mohamad L. Hammour (1994). "The Cleansing Effect of Recessions." *The American Economic Review*, 84(5), 1350–1368.

Caballero, Ricardo J. and Mohamad L. Hammour (1996). "On the Timing and Efficiency of Creative Destruction." *The Quarterly Journal of Economics*, 111(3), 805–852.

Casacuberta, Carlos and Néstor Gandelman (2015). "Productivity, Exit, and Crisis in the Manufacturing and Service Sectors." *The Developing Economies*, 53(1), 27–43.

Collier, Paul and Benedikt Goderis (2009). "Structural Policies for Shock-Prone Developing Countries." CSAE Working Paper Series 2009-03, University of Oxford.

Dias, D. A., Carlos Robalo Marques, and Christine Richmond (2016a). "Misallocation and productivity in the lead up to the Eurozone crisis." *Journal of Macroeconomics*, 49, 46–70.

Dias, Daniel, Carlos Robalo Marques, and Christine Richmond (2016b). "A tale of two sectors: why is misallocation higher in services than in manufcaturing?" Working Paper 14, Banco de Portugal.

Diewert, W. Erwin (1980). "Aggregation problems in the measurement of capital." In *Measurement of Capital*, edited by Dan Usher, chap. 8, pp. 433–528. Chicago: University of Chicago Press.

Eichenbaun, Martin, Sergio Rebelo, and Carlos de Resende (2016). "The Portuguese crisis and the IMF." Background Paper BP/16-02/05, IEO - Independent Evaluation Office of the IMF.

Ericson, Richard and Ariel Pakes (1995). "Markov-Perfect Industry Dynamics: A Framework for Empirical Work." *The Review of Economic Studies*, 62(1), 53–82.

Eslava, Marcel, Arturo Galindo, Marc Hofstetter, and Alejandro Izquierdo (2015). "Scarring Recessions and Credit Constraints: Evidence from Colombian Plant Dynamics." mimeo.

Esteves, Paulo and Elvira Prades (2018). "Does export concentration matter in economic adjustment programs? Evidence from the euro-area." *Economic Modelling*, forthcoming.

Foster, Lucia, Cheryl Grim, and John Haltiwanger (2016). "Reallocation in the Great Recession: Cleansing or Not?" *Journal of Labor Economics*, 34(S1), S293–S331.

Foster, Lucia, John Haltiwanger, and C. J. Krizan (2001). "Aggregate Productivity Growth: Lessons from Microeconomic Evidence." In *New Developments in Productivity Analysis*, ed. Carles R. Hulten, Edward R. Dean, and Michael J. Harper, chap. 8, pp. 303–372. Chicago and London: University of Chicago Press.

Foster, Lucia, John Haltiwanger, and Chad Syverson (2008). "Reallocation, Firm Turnover, and Efficiency: Selection on Productivity or Profitability?" 98, 394–425.

Griffin, Naomi N. and Kazuhiko Odaki (2009). "Reallocation and productivity growth in Japan: revisiting the lost decade of the 1990s." *Journal of Productivity Analysis*, 31(2), 125–136.

Griliches, Zvi and Haim Regev (1995). "Firm productivity in Israeli industry 1979–1988." *Journal of Econometrics*, 65(1), 175 – 203.

Hallward-Driemeier, Mary and Bob Rijkers (2013). "Do crises catalyze creative destruction? Firm-level evidence from Indonesia." *The review of Economics and Statistics*, 95(5), 1788–1810.

Haltiwanger, John, Stefano Scarpeta, and Helena Schweiger (2008). "Assessing Job Flows Across Countries: The Role of Industry, Firm Size and Regulations." Working Paper 13920, NBER.

Hopenhayn, Hugo A. (1992). "Entry, Exit, and firm Dynamics in Long Run Equilibrium." *Econometrica*, 60(5), 1127–1150.

Hsieh, Chang-Tai and Peter J. Klenow (2009). "Misallocation and Manufacturing TFP in China and India." *The Quarterly Journal of Economics*, 124(4), 1403–1448.

Jovanovic, Boyan (1982). "Selection and the Evolution of Industry." *Econometrica*, 50(3), 649–670.

Kehrig, Matthias (2015). "The Cyclical Nature of the Productivity Distribution." mimeo, Duke University.

Levinsohn, James and Amil Petrin (2003). "Estimating Production Functions Using Inputs to Control for Unobservables." *The Review of Economic Studies*, 70(2), 317–341.

Liu, Lili and James R. Tybout (1996). "Productivity Growth in Chile and Colombia: The Role of Entry, Exit, and Learning." In *Industrial Evolution in Developing Countries*, Mark J. Roberts and James R. Tybout ed., chap. 4, pp. 73–103. Oxford University Press.

Melitz, Marc J. and Saso Polanec (2015). "Dynamic Olley-Pakes Productivity Decomposition with Entry and Exit." *The RAND Journal of Economics*, 46(2), 362–375.

Mortensen, Dale T. and Christopher A. Pissarides (1994). "Job Creation and Job Destruction in the Theory of Unemployment." *The Review of Economic Studies*, 61(3), 397–415.

Nishimura, Kiyohiko G., Takanobu Nakajima, and Kozo Kiyota (2005). "Does the natural selection mechanism still work in severe recessions?: Examination of the Japanese economy in the 1990s." *Journal of Economic Behavior & Organization*, 58(1), 53 – 78.

OECD (2017). *Labour Mrket Reforms in Portugal 2011-2015, A Preliminary Assessment*. Organization for Economic Co-operation and Development, Paris.

Olley, G. Steven and Ariel Pakes (1996). "The Dynamics of Productivity in the Telecommunications Equipment Industry." *Econometrica*, 64(6), 1263–1297.

Osborne, Jason W. (2002). "Notes on the use of data transmformation." *Practical Assessment, Research and Evaluation*, 8(6).

Osborne, Jason W. and Amy Overbay (2004). "The power of outliers (and why researchers should always check for them)." *Practical Assessment, Research and Evaluation*, 9(6).

Osotimehin, Sophie and Francesco Pappadà (2017). "Credit Frictions and The Cleansing Effect of Recessions." *The Economic Journal*, 127(602), 1153–1187.

Ouyang, Min (2009). "The scarring effect of recessions." *Journal of Monetary Economics*, 56(2), 184 – 199.

Petrin, Amil and James Levinsohn (2012). “Measuring aggregate productivity growth using plant-level data.” *RAND Journal of Economics*, 43(4), 705–725.

Rajan, Raghuram G. and Luigi Zingales (1998). “Financial Dependence and Growth.” *The American Economic Review*, 88(3), 559–586.

Reis, Ricardo (2013). “The Portuguese Slump and Crash and the Euro Crisis.” *Brookings Papers on Economic Activity*, 46(1, Spring), 143–210.

Schumpeter, Joseph A. (1939). *Business Cycles: A Theoretical, Historical, and Statistical Analysis of the Capitalist Process.* 2 vols ed., New York: MacGraw Hill.

Schumpeter, Joseph A. (1942). *Capitalism, Socialism and Democracy.* New York: Harper.

Appendix A: Measuring productivity at the firm level

This Appendix describes the details regarding the definition of our two productivity measures, including the discussion of some estimation, interpretation, and aggregation issues. The labor productivity measure is defined as the log difference of real value added and employment (number of employees), and TFP is computed as the estimated residuals of a three input Cobb-Douglas production function:

$$lnTFP_{it} = lnQ_{it} - \alpha_K lnK_{it} - \alpha_L lnL_{it} - \alpha_M lnM_{it} \tag{A1}$$

where Q is real gross output, K is real capital, L is the number of employees, and M is real intermediate consumption.

The elasticities α_j $(j = K, L, M)$ are estimated at the industry level using the Levinsohn-Petrin estimator (see Levinsohn and Petrin (2003)), to account for the endogeneity of the regressors (inputs). Note that this estimation method does not impose constant returns to scale (CRS), and, based on our estimates, CRS is rejected for a large number of industries.[28]

Total factor productivity is our preferred measure of productivity. Labor productivity is easy to calculate and interpret, but its main drawback is that it can be a biased indicator when a resource-substitution effect exists. In fact, under the assumption of constant returns to scale (for ease of presentation), equation (A1) can be rewritten as:

$$ln\left(Q_{it}/L_{it}\right) = lnTFP_{it} + \alpha_K ln\left(K_{it}/L_{it}\right) + \alpha_M ln\left(M_{it}/L_{it}\right) \tag{A2}$$

which shows that changes in labor productivity may stem from changes in TFP, but also from changes in capital intensity or/and intermediate consumption intensity. Thus, reallocation of employment towards high labor productivity firms may arise from a shift towards more capital intensive firms, rather than from a reallocation of resources towards high TFP firms. The use of TFP as a measure of productivity, however, also raises important issues, as it is not observable and it must be estimated conditional on a given production function and on specific econometric estimators.

Quantity versus revenue productivity

An important issue regarding the computation of firm-level productivity is how to compute real gross output (or real value added) at the firm level. As firm-level prices are unobserved, real gross output at firm level is obtained by deflating nominal output using an industry-level price deflator. The implication

28. As robustness checks, we also computed TFP using the OLS estimates and the input shares. The qualitative conclusions obtained in this paper for these alternative TFP measures do not depend on the estimation method used.

is that our productivity measure obtained from equation (A1) is a revenue measure and not a physical or quantity productivity measure.[29] If firms face a differentiated product environment, we may expect an inverse relationship between physical productivity and firm-level prices. In such a case, our measure of productivity, obtained from equation (A1), will tend to underestimate the physical productivity of more productive firms (because such firms tend to charge lower prices). A similar phenomenon might occur with young firms. The evidence in the literature (see Foster *et al.* (2008)) suggests that young firms also tend to charge lower prices relative to older firms. This depresses the measurement of the physical output of entrants relative to incumbents and thus, may affect the results for the productivity decompositions (namely the relative contribution of entrants). After all, our measure of firm-level productivity should be interpreted as reflecting not only technical efficiency but also any other factors (like demand factors) that translate into firm-level prices.

Another important consequence occurs in the environment of monopolistic competition with a CRS Cobb-Douglas production function, as considered in Hsieh and Klenow (2009). In this case, changes in efficiency (i.e., quantity productivity) yield a proportional decline in prices, and in equilibrium, revenue productivity (TFPR) is constant across firms in the industry. In such a framework, TFPR differences across firms signal misallocation of resources stemming from distortions on input prices and/or frictions like adjustment costs of inputs or output-price rigidities.[30] Firms with higher TFPR are interpreted as facing higher distortions, so that changes in TFPR may signal changes in TFP but also changes in distortions. These are important aspects that must be kept in mind when evaluating some of the results presented in this paper.

Appendix B: Computing aggregate productivity using firm-level productivities

In order to get industry-level or economy-wide average productivity measures, we need to choose the weights, θ_{it}, to be used in equation (1), in the main text. When aggregating (averaging) labor productivity measures, employment (or hours worked) emerges as the natural choice as it allows reproducing exactly average productivity that we get from aggregate industry data, i.e., dividing industry-level output by industry-level employment. However, sometimes gross output or gross value added have also been used as weights (as a complement

29. Revenue productivity, $(TFPR_{it})$, is defined as price times quantity productivity, i.e., $TFPR_{it} = P_{it}TFP_{it}$ where P_{it} stands for the firm-level output price. If we use the industry-level price index, $\bar{P}_t$, to deflate nominal gross output, instead of $lnTFP_{it}$ on the right-hand side of equation (A1), we will get $ln(TFPR^*_{it}) = ln((P_{it}TFP_{it})/\bar{P}_t)$, which corresponds to revenue productivity of firm i up to a scalar, $\bar{P}_t$, common to all firms in the industry.

30. See, Dias *et al.* (2016a,b) for a detailed discussion and an application to Portugal.

or as an alternative to employment) to obtain aggregate measures of labor productivity (see Foster *et al.* (2001), Griffin and Odaki (2009), Hallward-Driemeier and Rijkers (2013)).

When aggregating (averaging) firm-level TFP at the industry- or sector-level, two essentially distinct types of weights have been used: the gross-output or value-added (real or nominal) shares (Baily *et al.* (1992), Foster *et al.* (2001), Olley and Pakes (1996), Griffin and Odaki (2009), Hallward-Driemeier and Rijkers (2013), Melitz and Polanec (2015)) and the input-mix shares (Liu and Tybout (1996) and Bartelsman and Dhrymes (1998)). Important empirical results, involving the components of the productivity decompositions discussed in this paper, have been shown to depend on the choice of the weights (see, for instance, Foster *et al.* (2001) and Griffin and Odaki (2009)), so that it is important to discuss the pros and cons of their use.

Let us assume the industry s with N firms, where the firm-level production function is assumed to be of the Cobb-Douglas type:[31]

$$Y_i = TFP_i K_i^{\alpha} L_i^{\beta}, \quad i = 1, 2, .., N \tag{A3}$$

Following the literature, we may define the industry-level production function as follows:

$$Y_s = TFP_s K_s^{\alpha} L_s^{\beta} \tag{A4}$$

where $X_s = \sum_{i=1}^{N} X_i, \;\; X = Y, K, L$ and TFP_s is, by definition, industry-level average TFP.[32] From A4, we can now express TFP_s as follows:

$$TFP_s = \frac{Y_s}{K_s^{\alpha} L_s^{\beta}} = \frac{\sum_i^N Y_i}{K_s^{\alpha} L_s^{\beta}} = \sum_i^N \left(\frac{K_i}{K_s}\right)^{\alpha} \left(\frac{L_i}{L_s}\right)^{\beta} TFP_i = \sum_i^N \theta_i^* TFP_i \tag{A5}$$

Equation (A5) shows that in order to recover TFP_s using firm-level productivity, (TFP_i), one should use weights $\theta_i^* = (K_i^{\alpha} L_i^{\beta})/(K_s^{\alpha} L_s^{\beta})$. A minor problem with this approach, however, is that, due to nonlinear aggregation, the weights θ_i^* will not, in general, add up to one exactly, which is a condition required in the above decompositions. In order to overcome this problem, we may define instead

$$TFP_s^* = \sum_i^N \frac{K_i^{\alpha} L_i^{\beta}}{\sum_i^N K_i^{\alpha} L_i^{\beta}} TFP_i = \sum_i^N \theta_i TFP_i \tag{A6}$$

where the weights:

$$\theta_i = \frac{K_i^{\alpha} L_i^{\beta}}{\sum_i^N K_i^{\alpha} L_i^{\beta}} \tag{A7}$$

31. For ease of presentation, here we stick to a value-added production function with two inputs, but nothing would change if a gross-output production function with three inputs were used, instead.

32. See, for instance, Hsieh and Klenow (2009).

add up to one. For the purpose of the present paper the θ_i are denoted as the input-mix shares. We have $\theta_i^* = \theta_i$ if and only if $\sum_i^N K_i^\alpha L_i^\beta/(K_s^\alpha L_s^\beta) = 1$, but in practice, we do not expect weights θ_i and θ_i^* to differ significantly from each other.[33] Thus, using the weights θ_i in equation (1) generates aggregate (average) TFP measures that closely match average aggregate productivity, as defined in equation (A4). But what if output shares are used as weights, instead, as is also common in the literature?.[34] If we use value added shares as the weights to compute aggregate productivity, we get (using equation (A3):

$$TFP_s^{**} = \sum_i^N \frac{Y_i}{\sum_i^N Y_i} TFP_i = \sum_i^N \frac{TFP_i}{TFP_s^*} \theta_i TFP_i = \sum_i^N \theta_i^{**} TFP_i \qquad \text{(A8)}$$

where $\theta_i^{**} = \frac{TFP_i}{TFP_s^*}\theta_i$ and TFP_s^* is given by (A6).

Equation (A8) differs from equation (A6) in some important dimensions. First, we note that equation (A8) does not match the definition of aggregate productivity, presented in (A4), as closely as equation (A6) does. The weights θ_i^{**}, which are a combination of the inputs used, (θ_i), and of the firm-level relative productivity (TFP_i/TFP_s^*), imply that firms with productivity above average productivity (as given by equation (A6)) receive higher weights and firms with productivity below average receive lower weights than implied by the amount of inputs used. This is likely to make (A8) a biased estimator of aggregate productivity in comparison with (A4): if on average larger firms are more productive than smaller firms (with size measured by the amount of labor or capital inputs), we expect larger firms to receive disproportionately higher weights and smaller firms disproportionately smaller weights compared to equations (A5) or (A6). Second, TFP_s^{**} is expected to be more sensitive to measurement errors than TFP_s^*. A positive outlier in output will yield a spuriously high positive change in TFP_i and in the share, θ_i^{**}, but θ_i is not affected by the measurement error. In turn, a positive measurement error in employment (or capital) reduces TFP_i, but the corresponding increase in the weights in the TFP_s^* case creates a compensation effect that is not present in TFP_s^{**}. Thus, measures that use output shares as weights (gross output or value added) are expected to make firm-level contributions more sensitive to the

33. It is easy to show that $\sum_i^N K_i^\alpha L_i^\beta/(K_s^\alpha L_s^\beta) = 1$ if capital intensity is the same for all firms in the industry $(K_i/L_i = K_j/L_j)$ and there are constant returns to scale.

34. The use of gross-output or gross value-added shares to compute aggregate TFP can be motivated in the context of a competitive environment with CRS production functions, where firms face the same output and input prices. Diewert (1980) (section 8.5.3) shows that under such conditions the appropriate weight for each firm is their share of industry revenue (nominal gross output or nominal value added) which is equivalent to their share of industry real gross output or real value added.

presence of measurement errors.[35] Finally, and we believe this is an important drawback, the use of TFP_s^{**} makes the interpretation of the productivity decompositions presented in equation (3), in the main text, less clear-cut. In particular, the interpretation of the between and cross effects (and thus, of the within effects) is blurred by the fact that changes in the weights can be the result of changes in productivity (TFP_i) and not the result of resource (input) reallocation across firms (changes in L_i or K_i).

The above discussion justifies our preference for the use of the input-mix shares as the weights in our aggregate TFP measures. However, as a robustness check we also compute an aggregate TFP measure using gross output shares as weights.

But, of course, the above discussion does not prevent our aggregate productivity measures, and especially the individual components of the corresponding decompositions (cross, between and within terms) of being individually affected by the presence of measurement errors in the relevant variables (gross output and inputs). Thus, in order to further attenuate the impact of outliers on our aggregate productivity measures and their decompositions, we use the shares of log employment and of log "input mix" as weights to compute aggregate labor productivity and aggregate TFP measures, respectively.

The use of the log transformation has been suggested as an alternative to trimming or winsorizing to deal with outliers. By permitting extreme values to be kept in the data set, it avoids the uncertainty associated with the choice of the trimming or winsorizing thresholds. The use of the log transformation has also been suggested as way to correct for the skewness of positively skewed distributions (see Osborne (2002) and Osborne and Overbay (2004)). The log transformation compresses the distribution of the weights around the "average" firm, reducing the importance of the largest firms and increasing the importance of the smallest firms. In an industry (or economy) characterized by the presence of many small firms and a few very large firms (right skewed distribution), this transformation may prevent aggregate productivity measures from being fully dominated by productivity developments of a small number of big firms.

In summary, by using the shares of log employment or log input mix as weights, we generate aggregate productivity measures that a) may be thought of as yielding the productivity developments of a "representative" or "average" firm and b) are robust to outliers (measurement errors) affecting inputs (employment, capital stock or intermediate inputs).

35. In a similar manner, aggregate labor productivity with employment shares as weights is less sensitive to measurement errors (outliers in employment or output) than aggregate labor productivity with output shares as weights.

Appendix C: Measuring the capital stock

To compute TFP we have to build a measure of the real capital stock. In our dataset, we have information on the book values of the net capital stock, which are not adequate for our purposes. Thus, we use the perpetual inventory method to calculate the capital stock. Specifically, we compute the real capital stock according to the following formula (for firm i in industry s) :

$K_{ist} = (1 - \delta_s)K_{is,t-1} + (I_{ist}/PI_t)$

where I_{ist} denotes gross fixed capital formation, δ_s is the industry level depreciation rate and PI_t is the investment goods deflator. However, for firms that started to operate before 2006 (the first year of our dataset), we correct the initial capital stock by a sector-specific adjustment coefficient that varies according to the age of the firm. Suppose that two firms in the data set in 2006, one that is 10 years old and the other that is just 2 years old. The book values of capital are not comparable, because they refer to different generations of capital, bought in different years and at different prices. Thus, simply deflating the book values of the capital stock in the first year of the sample for all firms, irrespective of their age, introduces an important measurement error in the real capital stock. We used information on the book values of the capital stock and investment from other data sources for a large sample of firms and apply the inventory method starting in the first year of operation of such firms.[36] This allows us to construct an industry-specific adjustment coefficient (ratio of real capital stock to the book-values capital stock) that varies according to the age of the firm, and that is used to estimate the firm-level real capital stock in 2006.[37]

36. The data sources are from *Instituto Nacional de Estatística* (INE), the Portuguese Statistics Institute, and covers the period 1996 to 2005. The source of the information for the 1996-2004 subperiod is the *Inquérito à Empresa Harmonizado* (IEH), while for the 2004-2005 subperiod the information comes from the *Sistema de Contas Integradas das Empresas* (SCIE). The two sources of data provide very detailed information on the firm's balance sheet and income statement and were used in Dias *et al.* (2016a).

37. For firms that started to operate before 1966, we assume that this was their first year, as we do not have information before 1996.

Appendix D: Additional productivity decompositions

	Tradable Services			Nontradable Services		
Components	Pre-crisis (2006-2010)	Crisis (2011-2012)	Recovery (2013-2015)	Before (2006-2010)	Crisis (2011-2012)	Recovery (2013-2015)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Within	0.29	-7.61	1.66	2.55	-1.44	4.41
Between	2.86	2.77	2.42	2.22	2.51	2.12
Cross	-4.71	-4.38	-4.56	-3.53	-3.17	-3.31
Net-entry	-1.02	0.55	0.06	-1.70	-0.42	-1.13
Entry	-2.62	-1.49	-1.82	-3.55	-3.23	-4.12
Exit	1.60	2.05	1.88	1.85	2.81	2.99
Total	-2.58	-8.67	-0.42	-0.46	-2.52	2.09

TABLE A1. Labor productivity decomposition (tradable and nontradable services): average annual contributions

Note: Labor productivity refers to value-added per employee; the weights are the shares of log employment; The service sector does not include construction nor utilities (electricity, gas and water services).

	Tradable Services			Nontradable Services		
Components	Pre-crisis (2006-2010)	Crisis (2011-2012)	Recovery (2013-2015)	Pre-crisis (2006-2010)	Crisis (2011-2012)	Recovery (2013-2015)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Within	-0.59	-3.11	0.57	0.23	-0.52	2.17
Between	0.59	0.48	0.50	0.60	0.72	0.57
Cross	-0.59	-0.59	-0.62	-0.93	-1.02	-1.34
Net-entry	1.41	2.58	2.62	-1.67	0.05	-0.56
Entry	1.24	1.89	1.86	-3.34	-2.34	-2.93
Exit	0.16	0.69	0.76	1.66	2.39	2.38
Total	0.82	-0.64	3.07	-1.77	-0.77	0.84

TABLE A2. TFP decomposition (tradable and nontradable services): average annual contributions

Note: TFP refers to gross-output with weights given by the shares of log input mix. The service sector does not include construction nor utilities (electricity, gas and water services).

Components	Labor Productivity			TFP		
	Pre-crisis (2006-2010)	Crisis (2011-2012)	Recovery (2013-2015)	Pre-crisis (2006-2010)	Crisis (2011-2012)	Recovery (2013-2015)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Within	1.54	-0.85	2.76	-0.40	-1.79	1.09
Between	1.42	2.38	1.35	-0.18	-0.15	-0.19
Cross	-3.09	-3.22	-3.28	0.38	0.51	0.53
Net-entry	-0.22	0.33	-0.03	-1.03	0.16	0.34
Entry	-2.17	-2.05	-2.27	-1.32	-0.72	-0.89
Exit	1.95	2.37	2.24	0.29	0.88	1.22
Total	-0.35	1.36	0.80	-1.23	-1.26	1.76

Table A3. Productivity decompositions (total economy): average annual contributions

Note: Labor productivity refers to value-added per employee, using the shares of employment as weights; TFP refers to gross-output, using the shares of log nominal gross output as weights.

Components	Manufacturing			Services		
	Pre-crisis (2006-2010)	Crisis (2011-2012)	Recovery (2013-2015)	Before (2006-2010)	Crisis (2011-2012)	Recovery (2013-2015)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Within	1.82	0.05	1.96	1.76	-1.60	3.19
Between	1.30	1.29	0.93	1.44	2.69	1.42
Cross	-1.45	-1.36	-1.34	-3.70	-3.77	-3.73
Net-entry	0.67	1.21	0.20	-0.48	-0.19	-0.14
Entry	-1.24	-1.15	-1.66	-2.36	-2.29	-2.28
Exit	1.91	2.36	1.85	1.88	2.10	2.15
Total	2.34	1.19	1.75	-0.98	-2.87	0.74

Table A4. Labor productivity decomposition (manufacturing and services): average annual contributions

Note: Labor productivity refers to value-added per employee; the weights are the shares of employment; The service sector does not include construction nor utilities (electricity, gas and water services).

Components	Manufacturing			Services		
	Pre-crisis (2006-2010)	Crisis (2011-2012)	Recovery (2013-2015)	Pre-crisis (2006-2010)	Crisis (2011-2012)	Recovery (2013-2015)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Within	0.04	-1.32	0.62	-0.42	-1.80	1.29
Between	0.05	0.29	0.06	-0.15	-0.13	-0.22
Cross	0.23	0.34	0.35	0.39	0.51	0.54
Net-entry	-0.68	0.67	1.42	-0.88	0.61	0.41
Entry	1.14	1.40	1.60	-2.04	-1.16	-1.48
Exit	-1.83	-0.73	-0.18	1.15	1.77	1.88
Total	-0.36	-0.02	2.45	-1.06	-0.81	2.02

Table A5. TFP decomposition (manufacturing and services): average annual contributions

Note: TFP refers to gross-output with weights given by the shares of log nominal gross output. The service sector does not include construction nor utilities (electricity, gas and water services).

Working Papers

2016

1|16 A mixed frequency approach to forecast private consumption with ATM/POS data
Cláudia Duarte | Paulo M. M. Rodrigues | António Rua

2|16 Monetary developments and expansionary fiscal consolidations: evidence from the EMU
António Afonso | Luís Martins

3|16 Output and unemployment, Portugal, 2008–2012
José R. Maria

4|16 Productivity and organization in portuguese firms
Lorenzo Caliendo | Luca David Opromolla | Giordano Mion | Esteban Rossi-Hansberg

5|16 Residual-augmented IVX predictive regression
Matei Demetrescu | Paulo M. M. Rodrigues

6|16 Understanding the public sector pay gap
Maria M. Campos | Evangelia Papapetrou | Domenico Depalo Javier J. Pérez | Roberto Ramos

7|16 Sorry, we're closed: loan conditions when bank branches close and firms transfer to another bank
Diana Bonfim | Gil Nogueira | Steven Ongena

8|16 The effect of quantitative easing on lending conditions
Laura Blattner | Luísa Farinha | Gil Nogueira

9|16 Market integration and the persistence of electricity prices
João Pedro Pereira | Vasco Pesquita | Paulo M. M. Rodrigues | António Rua

10|16 EAGLE-FLI | A macroeconomic model of banking and financial interdependence in the euro area
N. Bokan | A. Gerali | S. Gomes | P. Jacquinot | M. Pisani

11|16 Temporary contracts' transitions: the role of training and institutions
Sara Serra

12|16 A wavelet-based multivariate multiscale approach for forecasting
António Rua

13|16 Forecasting banking crises with dynamic panel probit models
António Antunes | Diana Bonfim | Nuno Monteiro | Paulo M. M. Rodrigues

14|16 A tale of two sectors: why is misallocation higher in services than in manufacturing?
Daniel A. Dias | Carlos Robalo Marques | Christine Richmond

15|16 The unsecured interbank money market: a description of the Portuguese case
Sofia Saldanha

16|16 Leverage and risk weighted capital requirements
Leonardo Gambacorta | Sudipto Karmakar

17|16 Surviving the perfect storm: the role of the lender of last resort
Nuno Alves | Diana Bonfim | Carla Soares

18|16 Public debt expansions and the dynamics of the household borrowing constraint
António Antunes | Valerio Ercolani

2017

1|17 The diffusion of knowledge via managers' mobility
Giordano Mion | Luca David Opromolla | Alessandro Sforza

2|17 Upward nominal wage rigidity
Paulo Guimarães | Fernando Martins | Pedro Portugal

3|17 Zooming the ins and outs of the U.S. unemployment
Pedro Portugal | António Rua

4|17 Labor market imperfections and the firm's wage setting policy
Sónia Félix | Pedro Portugal

5|17 International banking and cross-border effects of regulation: lessons from Portugal
Diana Bonfim | Sónia Costa

6|17 Disentangling the channels from birthdate to educational attainment
Luís Martins | Manuel Coutinho Pereira

7|17 Who's who in global value chains? A weighted network approach
João Amador | Sónia Cabral | Rossana Mastrandrea | Franco Ruzzenenti

8|17 Lending relationships and the real economy: evidence in the context of the euro area sovereign debt crisis
Luciana Barbosa

9|17 Impact of uncertainty measures on the Portuguese economy
Cristina Manteu | Sara Serra

10|17 Modelling currency demand in a small open economy within a monetary union
António Rua

11|17 Boom, slump, sudden stops, recovery, and policy options. Portugal and the Euro
Olivier Blanchard | Pedro Portugal

12|17 Inefficiency distribution of the European Banking System
João Oliveira

13|17 Banks' liquidity management and systemic risk
Luca G. Deidda | Ettore Panetti

14|17 Entrepreneurial risk and diversification through trade
Federico Esposito

15|17 The portuguese post-2008 period: a narrative from an estimated DSGE model
Paulo Júlio | José R. Maria

16|17 A theory of government bailouts in a heterogeneous banking system
Filomena Garcia | Ettore Panetti

17|17 Goods and factor market integration: a quantitative assessment of the EU enlargement
FLorenzo Caliendo | Luca David Opromolla | Fernando Parro | Alessandro Sforza

2018

18|18 Every cloud has a silver lining: Micro-level evidence on the cleansing effects of the Portuguese financial crisis

Daniel A. Dias | Carlos Robalo Marques

www.bportugal.pt