BANK FOR INTERNATIONAL SETTLEMENTS

BIS Working Papers

No 534

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December 2015

JEL classification: E24; E51; O47

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This publication is available on the BIS website (www.bis.org).

ISSN 1020-0959 (print)
ISSN 1682-7678 (online)

Labour reallocation and productivity dynamics: financial causes, real consequences[1]

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Abstract

We investigate the link between credit booms, productivity growth, labour reallocations and financial crises in a sample of over twenty advanced economies and over forty years. We produce two key findings. First, credit booms tend to undermine productivity growth by inducing labour reallocations towards lower productivity growth sectors. A temporarily bloated construction sector stands out as an example. Second, the impact of reallocations that occur during a boom, and during economic expansions more generally, is much larger if a crisis follows. In other words, when economic conditions become more hostile, misallocations beget misallocations. These findings have broader implications: they shed light on the recent secular stagnation debate; they provide an alternative interpretation of hysteresis effects; they highlight the need to incorporate credit developments in the measurement of potential output; and they provide a new perspective on the medium- to long-run impact of monetary policy as well as its ability to fight post-crisis recessions.

Keywords: Labour reallocation, productivity, credit booms, financial crises, hysteresis.

JEL codes: E24; E51; O47

1 The authors thank Martin Brown, Andy Filardo, Paloma Garcia, Jonathan Kearns, Gianni Lombardo, José-Luis Peydró, Thijs van Rens and seminar participants at Banque de France, Bank of Portugal, the BoC-ECB conference on "The underwhelming global post-crisis growth performance – determinants, effects and policy implications", the CEPR conference on "Persistent output gaps: causes and policy remedies", the University of St. Gallen conference on "Finance, capital reallocation and growth". The views expressed here are those of the authors and do not necessarily represent the views of the BIS.

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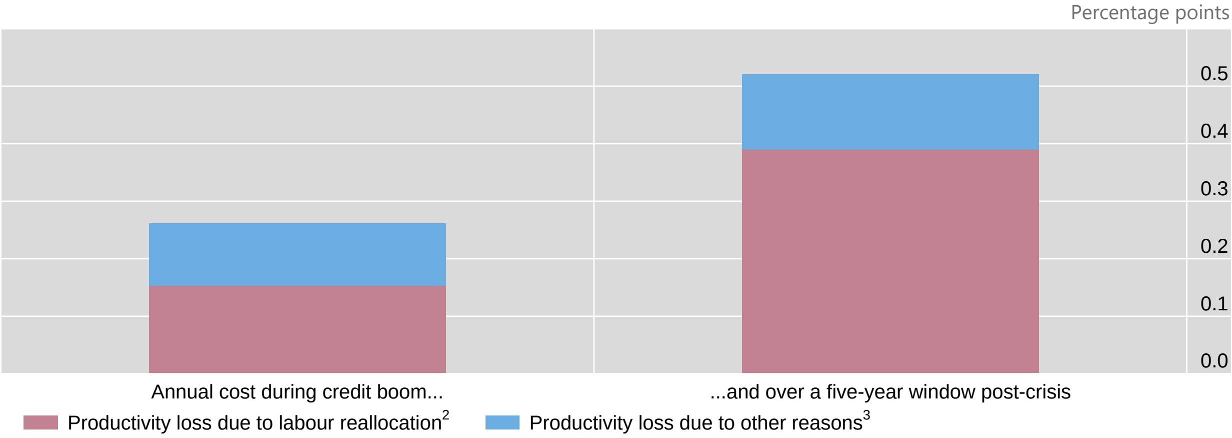
1. Introduction

By now, it is well known that credit booms can seriously damage an economy's health. Most of the evidence so far has related to the booms' aftermath. Rapid credit growth substantially increases the risk of financial (banking) crises (eg Borio and Lowe (2002), Cecchetti et al (2009) Drehmann et al (2011), Gourinchas and Obstfeld (2012), Mian and Sufi (2009)). And banking crises preceded by credit booms tend to be followed by larger output losses and shallower recoveries (Jorda et al (2013), Reinhart and Rogoff (2011)). Moreover, the impact of banking crises on output is very long-lasting, if not permanent (BCBS (2010)).

More recent evidence also suggests that credit booms may damage the economy even as they occur by reducing productivity growth, regardless of whether a crisis follows (Cecchetti and Kharroubi (2015)). The mechanisms are not well understood, but Cecchetti and Kharroubi conjecture that the allocation of resources plays a key role. The financial sector's expansion may benefit disproportionately projects with high collateral but low productivity. And financial institutions' high demand for skilled labour may crowd out more productive sectors. Both mechanisms are in line with empirical evidence that during financial booms productivity growth falls disproportionately in manufacturing industries that are either R&D intensive or hold less tangible assets.

In this paper we investigate the empirical link between credit booms, financial crises and productivity growth more closely. We focus on labour reallocations *across* sectors, although *within-sector* effects may also be important. Specifically, we ask two questions. First, during credit booms, does labour shift to lower productivity growth sectors? And second, does a financial crisis amplify the effect of labour reallocations that took place during the previous economic expansion? The answer to both of these questions is a clear "yes". At least, this is the conclusion based on a sample of 21 advanced economies over the period 1969 to the present.

Credit booms sap productivity growth through labour reallocation[1] Graph 1



[1] Estimates calculated over the period 1969–2013 for 21 advanced economies, assuming a five-year credit boom followed by a financial crisis. [2] Annual impact on productivity growth of labour shifts into less productive sectors during a five-year credit boom. [3] Annual impact in the absence of labour reallocations during the boom.

Source: Authors' calculations.

Graph 1 summarises our key findings. To help fix ideas, it shows the impact on productivity of a synthetic credit boom-cum-financial crisis episode – specifically, the impact of an assumed 5-year credit boom that is followed by a financial crisis, and considering a 5-year post-crisis window.[3]

Three points stand out. First, credit booms tend to undermine productivity growth as they occur. For a typical credit boom, a loss of just over a quarter of a percentage point per year is a kind of lower bound. Second, a large part of this, slightly less than two thirds, reflects the shift of labour to lower productivity growth sectors – this is the only statistically significant component. Think, for instance, of shifts into a temporarily bloated construction sector. The remainder is the impact on productivity that is common across sectors, such as the shared component of aggregate capital accumulation and of total factor productivity (TFP). Third, the subsequent impact of labour reallocations that occur during a boom is much larger if a crisis follows. The average loss per year in the five years after a crisis is more than twice that during a boom, around half a percentage point per year. Put differently, the reallocations cast a long shadow. Taking the 10-year episode as a whole, the cumulative impact amounts to a loss of some 4 percentage points. Regardless of the specific figure, the impact is clearly sizeable. The findings are robust to alternative definitions of credit booms, to the inclusion of control variables and to techniques to identify the direction of causality.

While our results are quite general, it is easy to identify obvious recent examples of these mechanisms at work. The credit booms in Spain and Ireland in the decade to 2007 coincided with the rapid growth of employment in construction and real estate services at the expense of the more productive manufacturing sector. Once the boom turned to bust and the financial crisis struck, the economies went through a painful rebalancing phase, as resources had to shift back under adverse conditions – not least a broken financial system that did not facilitate, indeed may well have hindered, the process. In this sense, the reallocations of resources during the boom were clearly misallocations (we will use the terms interchangeably in what follows).

Technically, we proceed in two stages. First, we build on Olley and Pakes (1996) in decomposing aggregate labour productivity growth into a common and an allocation component – purely an identity.[4] The common component reflects the unweighted average of productivity growth across all industries in the economy. The allocation component measures the impact of labour reallocations across industries.[5] For instance, a shift of labour from low to high productivity industries will lead to a positive allocation component. Because of data limitations, and in order to capture

3 We consider a one standard deviation increase in private credit to GDP growth and derive the implied slowdown in labour productivity as well as in the corresponding common and allocation components using Table 3 estimates. Then, using Table 10 estimates, we use the implied changes in labour productivity growth components to compute the percentage deviation in labour productivity that the economy would face five years after a financial crisis.

4 Bartelsman et al. (2013) provides a study of the determinants of cross-country differences in productivity using the Olley and Pakes (1996) decomposition.

5 Strictly speaking, as will be clear in section 2, the allocation component is the covariance across sectors between the growth rate of the sectoral employment share and the growth rate of sectoral productivity. Hence, in theory, it measures both the impact of labour reallocation across sectors and that of changes in productivity growth across sectors. In practice, however, the data show that changes in the allocation component are essentially driven by changes in the distribution of labour across sectors. That is why we use this shortcut, stating that the allocation component measures the impact of labour reallocations across industries.

as many credit boom episodes as possible, we focus on the one-digit industry level. Admittedly, this is a relatively coarse classification – for instance, the entire manufacturing sector is lumped together and banks are merged with other financial services.

Armed with these decompositions, we use a series of panel techniques to dissect the impact of credit booms on productivity growth. We first explore the impact of credit booms on the productivity components as the booms proceed. We then examine the impact of the various productivity components during pre-recession economic expansions on the subsequent path of productivity, depending on whether crises occur. We naturally control for various other factors, including the independent impact of a crisis.

This paper builds on two different strands of the literature on the effect of resource reallocations. The first quantifies job reallocations and explores their causes and consequences. Davis and Haltiwanger (1992) estimate that roughly 20% of US manufacturing jobs are created or destroyed per year. Campbell and Kuttner (1996) find that reallocation shocks account for roughly half of the variance in total employment growth. A large literature examines the relationship between reallocations and the business cycle to tease out causality (see for instance Baily et al (2001) or Foster et al (2014)). More recently, a growing number of studies have begun to consider the effect of credit booms on such reallocations. Acharya et al (2010) delve into the effect of US cross-state banking deregulation on the allocation of output and employment across sectors at the state level. Gorton and Ordoñez (2014) find that credit booms can have negative implications for aggregate TFP: in their model this results from agents not producing information about the quality of collateral during the boom.

A second strand of the literature deals more generally with the macroeconomic implications of microeconomic distortions. In their seminal paper, Hsieh and Klenow (2009) estimate the dispersion of productivity within individual industries using firm-level data. They argue that this dispersion is indicative of resource misallocations, which in turn act as a drag on aggregate productivity. Hsieh and Klenow's approach has been extended in various directions, but the focus has generally been on misallocations within particular industries. Their results may therefore provide a lower bound of the effect of misallocations, although measurement error and other factors could work in the opposite direction (see Restuccia and Rogerson (2013), who also survey the subsequent literature).

Our approach differs from models in the Hsieh and Klenow tradition in at least two respects. We measure reallocation across sectors, not within individual industries. And we directly relate its contribution to productivity growth to one potential driver, namely rapid credit growth.

The papers most closely related to ours are Dias et al (2015) and Gopinath et al (2015). Dias et al (2015) extend Hsieh and Klenow's approach to include intermediate inputs in order to measure intra-industry misallocations in Portugal. They find that such misallocations almost doubled between 1996 and 2007, a period of rapid capital inflows. Gopinath et al (2015) find that flows of capital into Spain, triggered by low interest rates in the wake of European monetary unification, disproportionately benefited firms that had not been finance-constrained hitherto. The authors interpret the resulting higher dispersion of the marginal product of capital as pointing to resource misallocations.

Our paper is organised as follows. Section 2 presents the decomposition of labour productivity growth into its common and allocation components, describes the data, and casts a first glance at the behaviour of the two components. The details of the derivation are relegated to Annex 1. Section 3 explores how credit booms affect productivity growth by influencing its various components as the booms occur, at increasing degrees of granularity. Section 4 examines the implications of labour reallocations for the subsequent productivity path, paying special attention to how the occurrence of financial crises affects the link. The conclusion raises some broader questions and implications of the analysis.

2. Labour reallocations and productivity growth: decomposition, data and a first glance

2.1 The decomposition

We begin by defining the concept of labour reallocation we will be using throughout the paper (Annex). We rely on a simple decomposition of aggregate labour productivity growth. This is purely an identity. Denoting $y(y_s)$ aggregate output (sector s output) and $l(l_s)$ aggregate employment (sector s employment), the growth rate of labour productivity can be written as

$$1+\frac{\Delta(y/l)}{y/l}=\underbrace{\left[1+\overline{\frac{\Delta(l_s/l)}{l_s/l}\%}\right]\left[1+\overline{\frac{\Delta(y_s/l_s)}{\%y_s/l_s}\alpha_s}\right]}_{\text{common component}}+\underbrace{cov\left(\frac{\Delta(l_s/l)}{l_s/l};\left(1+\%\frac{\Delta(y_s/l_s)}{y_s/l_s}\right)\alpha_s\right)}_{\text{allocation component}} \quad (1)$$

where an upper bar denotes an unweighted average across sectors and $\alpha_s = y_s/\overline{y}$ is the ratio of sector s output to average output across sectors. The first term of the right-hand side in expression (1) is the common component of real labour productivity growth (henceforth, (com)). It is the product of the average growth rate in sector-level employment shares and the size-weighted average growth rate of productivity across sectors. The second term of the right-hand side in expression (1) is the allocation component (henceforth, ($alloc$)). It represents the covariance across sectors between the growth rate of sector-level employment shares and the sector-level size-weighted labour productivity growth. For a given distribution of sector sizes α_s, this term measures whether labour is reallocated towards high or low productivity growth sectors.

To illustrate this decomposition, we consider a hypothetical economy made up of two sectors, A and B, of equal output and employment size and three different scenarios (Table 1). All three scenarios assume that aggregate employment is constant, that productivity grows by 10 per-cent in sector B and that it drops by 10 per-cent in sector A. They differ only with respect to the assumed sectoral employment growth rates: in scenario 1, employment is constant in both sectors A and B; in scenario 2, employment grows by 10 per-cent in sector B, where productivity growth is positive, but drops by 10 per-cent in sector A, where it is negative; finally, in scenario 3, the opposite is true: employment grows by 10 per-cent in sector A .but drops by 10 per-cent in sector B.

A simple example of productivity growth decomposition

Table 1

Sector	Employment growth		Productivity growth		Aggregate Productivity growth	Emp./Prod. growth correlation
	A	B	A	B		A and B
Scenario 1	0	0	–10	+10	0	0
Scenario 2	–10	+10	–10	+10	+1	+1
Scenario 3	+10	–10	–10	+10	–1	–1

The scenarios have different implications for productivity growth. In scenario 1, employment is constant in both sectors, so aggregate productivity growth is just the simple average of productivity growth across sectors, which is zero. By contrast, in scenario 2, employment grows in the sector enjoying a productivity gain and drops in the sector facing a productivity loss. Thus, aggregate productivity is higher. Finally, in scenario 3, the opposite holds: employment grows in the sector suffering a productivity loss and drops in the sector facing a productivity gain. This results in negative aggregate productivity growth.

In these three scenarios, by construction, the common component as defined in decomposition (1) is equal to zero, since both average employment growth and average productivity growth across sectors are zero. Therefore, aggregate productivity growth is equal to the allocation component. This, in turn, is simply equal to the correlation across sectors between employment and productivity growth, consistent with decomposition (1).

We now turn to quantifying each of the terms in decomposition (1) based on available data.

2.2 The data

We rely on three different sources of industry-level data: the OECD-STAN database, the EU-KLEMS database and the GGDC 10-sector database. These three datasets provide information on value added and employment at the sector level following the ISIC 3 rev.1 classification at the 1-digit level. Overall, we consider 9 different sectors: Agriculture (A and B), Mining (C), Manufacturing (D), Utilities (E), Construction (F), Trade services (G and H), Transport services (I), Finance, Insurance and Real Estate services (J and K) and Government and Personal services (L to Q). To build our dataset, we require for each data point that industry-level output and employment sum up to the economy-wide aggregates. This limits the number of countries and years that can be included in the analysis.[6] We end up with an unbalanced sample covering 21 countries starting in 1979 and ending in 2009.[7]

Following the previous notation, using decomposition (1), aggregate real labour productivity growth in country i between year t and year $t+n$ can be written as

$$\frac{y_{i,t+n}/l_{i,t+n}}{y_{i,t}/l_{i,t}} = (com)_{i,t,t+n} + (alloc)_{i,t,t+n} \quad (2)$$

On the right-hand side, (com) represents the common component of productivity growth and $(alloc)$ represents the allocation component as defined in decomposition (1). To compute the various growth measures we consider non-overlapping periods of either three or five years. This is because reallocations must surely take considerable time, especially across industries as widely defined as those considered here.[8] Shorter periods, of, say, one or two years, could mask the "true" extent of the reallocations. Using 5-year windows yields 120 observations and 3-year windows 182 observations.

2.3 A first glance

Table 2 provides summary statistics – pooling all the data – for aggregate real labour productivity growth, ie the left-hand side in expression (1), and for its common and allocation components, ie respectively, the first and second terms on the right-hand side in expression (1). The first three columns of Table 2 provide summary statistics using 5-year windows and the last three using 3-year windows.

Over a 5-year interval, real labour productivity grows on average by 8.6 percent, ie 1.6 percent per year. On average, the common component represents around 5.4 percentage points (or just under two-thirds) and the allocation component the remaining 3.2 percentage points. The figures based on 3-year windows are similar: aggregate real labour productivity grows on average by 1.7 percent per year, with the common component representing two-thirds of the total.

6 In this paper we focus on *net* changes in sector-level employment, without separating employment destruction from employment creation. Another difference from the literature is that we focus on employment or persons employed as opposed to jobs. As a result, we are probably underestimating the extent of labour reallocation in the economy. For example, Davis and Haltiwanger (1992) estimate that each year around 20 percent of jobs are either created or destroyed in US manufacturing. By contrast, our net employment change barely represents a few percentage points of total employment in our sample.

7 The countries included in the sample are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the United States. The start and end dates (1979 and 2009) were chosen mainly because of constraints on industry data availability.

8 Blanchard and Katz (1992) consider the effect of state-specific shocks to labour demand across US states. According to their estimates, it can take up to 7 years for their effects on state unemployment and participation to disappear. More recently, based on longitudinal data, Walker (2013) estimates the transitional costs associated with reallocating workers from newly regulated industries to other sectors in the wake of new environmental regulations. His results suggest that these costs are significant: the average worker in a regulated sector experienced a total earnings loss equivalent to 20% of pre-regulatory earnings, with almost all of the estimated earnings losses driven by workers who separate from their firm.

Summary Statistics Table 2

	Productivity growth	Allocation component	Common component	Productivity growth	Allocation component	Common component
	5-year growth			3-year growth		
Average	8.61	3.24	5.37	5.25	1.87	3.38
Median	8.23	3.21	4.45	5.11	1.98	2.72
Standard deviation	6.27	2.76	6.69	4.51	2.10	4.93
Standard deviation (within)	4.74	2.41	4.75	3.64	1.97	3.94
Observations	120	120	120	182	182	182

Source: Authors' calculations.

The volatility (standard deviation) of the allocation component accounts for 45 to 55% of the volatility of aggregate productivity growth, depending on the window length. The common component is roughly as volatile as aggregate productivity growth, implying a negative covariance with the allocation component. This means that changes in the common component are systematically associated with opposite, but smaller, changes in the allocation component. For example, an economy-wide shock that raises productivity growth uniformly across all sectors tends to be partly offset by labour reallocations towards those with lower productivity growth.

Table 3 provides the correlation matrix for aggregate productivity growth and the two components, focusing on within-country correlations. Correlations in the upper left matrix are computed using 5-year windows; those in the lower right matrix using 3-year ones.

Correlation Matrix Table 3

		Productivity growth	Allocation component	Common component	Productivity growth	Allocation component	Common component
		5-year growth			3-year growth		
Productivity growth	5-year growth rates	1					
Allocation component		0.248***	1				
Common component		0.871***	–0.260***	1			
Productivity growth	3-year growth rates				1		
Allocation component					0.222***	1	
Common component					0.865***	–0.298***	1

Source: Authors' calculations.

The matrix shows that labour reallocations towards high productivity sectors tend to boost aggregate productivity growth. Aggregate productivity and its allocation component co-move positively within countries and the relationship is statistically significant.

3. Credit booms, labour reallocations and productivity growth

3.1 Relative impact on the allocation and common components of productivity

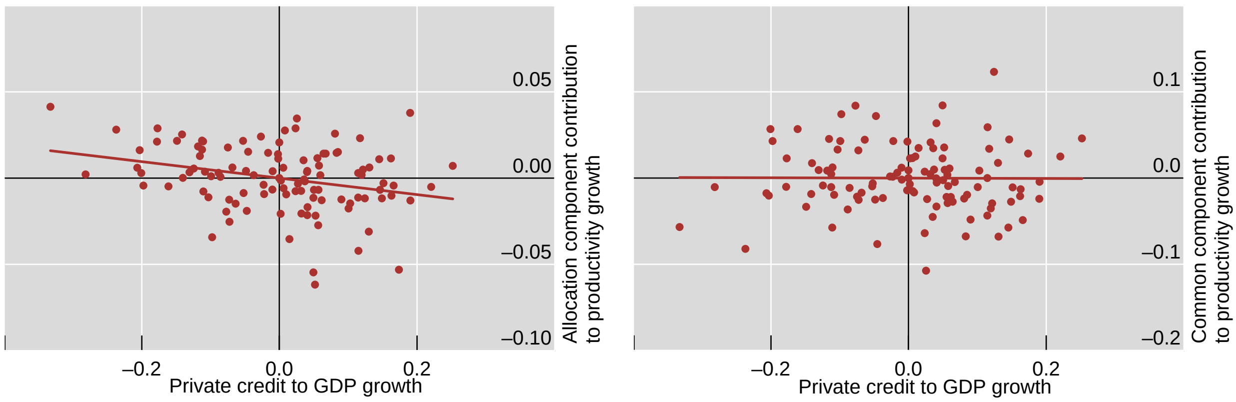
What is the impact of credit booms on the two components of productivity growth as the credit booms occur? Simply put, we find that credit booms depress productivity growth and that their impact works through the allocation component – the only one for which a statistically significant link is apparent. This result survives increasingly demanding tests.

The basic result emerges already quite clearly in simple bivariate tests.

Financial booms and productivity growth components

Computed over five-year windows and taken as deviations from country and period means — Graph 2

Credit booms and the allocation component — Credit booms and the common component



The left-hand panel plots the growth rate in private credit to GDP against the allocation component of labour productivity growth, both variables being taken as deviations from country and period means. The right-hand panel plots the growth rate in private credit to GDP against the common component of labour productivity growth, both variables being taken as deviations of from country and period means. The sample includes 21 economies (Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the United States) and six periods of five years (1979–84; 1984–89; 1989–94; 1994–99; 1999–2004; 2004–09)

Source: Authors' calculations.

Graph 2 plots the allocation component (left panel) and the common component (right panel), respectively, against the growth in credit to the private sector to GDP (shown on the x-axes) – our benchmark measure of credit expansion, the latter being drawn from the BIS database on credit to the non-financial private sector. We use 5-year windows and focus on deviations from country and time averages. The graph traces a negative and statistically significant relationship between credit growth and the allocation component. By contrast, no such relationship emerges with the common component.

To test whether these bilateral correlations survive a more rigorous econometric analysis, we estimate the following three regressions:

$$\frac{y_{i,t+n}/l_{i,t+n}}{y_{i,t}/l_{i,t}} = \alpha_i + \alpha_t + \beta x_{i,t} + \beta_l \frac{l_{i,t+n}}{l_{i,t}} + \theta \frac{f_{i,t+n}}{f_{i,t}} + \varepsilon_{i,t}^{y}$$

$$(alloc)_{i,t,t+n} = \alpha_{a,i} + \alpha_{a,t} + \beta_a x_{i,t} + \beta_{a,l} \frac{l_{i,t+n}}{l_{i,t}} + \theta_a \frac{f_{i,t+n}}{f_{i,t}} + \varepsilon_{i,t}^{a} \quad (3)$$

$$(com)_{i,t,t+n} = \alpha_{c,i} + \alpha_{c,t} + \beta_c x_{i,t} + \beta_{c,l} \frac{l_{i,t+n}}{l_{i,t}} + \theta_c \frac{f_{i,t+n}}{f_{i,t}} + \varepsilon_{i,t}^{c}$$

Here, $\frac{y_{i,t+n}/l_{i,t+n}}{y_{i,t}/l_{i,t}}$ stands for the growth rate of labour productivity in country i between year t and $t+n$, and $(alloc)_{i,t,t+n}$ and $(com)_{i,t,t+n}$ for the allocation and the common component, respectively. The independent variables include a set of country and time dummies $(\alpha_i;\alpha_t)$ as well as a vector of (pre-determined) control variables $x_{i,t}$.[9] The growth rate of employment in country i between year t and $t+n$ is denoted $\frac{l_{i,t+n}}{l_{i,t}}$ and $\frac{f_{i,t+n}}{f_{i,t}}$ is the variable measuring the intensity of the credit boom in country i between year t and $t+n$.[10]Finally, $\varepsilon's$ are residuals.

We estimate regressions (3) using the two different window-lengths, 3 and 5 years, and two different measures of credit booms, namely the rate of growth in the private credit-to-GDP ratio (our benchmark measure) and the deviation of the same ratio from its long-term trend (the "credit gap").[11]

The vector x of controls includes the following variables: (i) the ratio of credit to GDP; (ii) government size, measured as the ratio of government consumption to GDP; (iii) CPI inflation; (iv) openness to trade, measured as the ratio of imports plus exports to GDP; (v) a dummy for the occurrence of a financial crisis; and (vi) the log of the initial level of output per worker. These data are all drawn from the OECD *Economic Outlook* database, except the data on financial crises, which are drawn from Laeven and Valencia (2012).

The choice of control variables deserves some explanation. Credit in relation to GDP can help avoid confusing the effect of credit levels and growth. If, say, the growth rate in the credit-to-GDP ratio is lower when the credit-to-GDP ratio is higher, then a negative correlation between our measure of credit booms and productivity growth could simply reflect the positive effect of a higher credit-to-GDP ratio. We include government expenditures because credit booms boost tax revenues, allowing the government to increase its spending and employment. Since, by construction, the government sector exhibits low productivity growth, the negative correlation identified above might just be capturing changes in its size. The addition of inflation

9 Note that including country fixed effects ensures we focus on within-country credit booms while including time fixed effects ensures we focus on country-specific credit booms and filter out global ones.

10 Aggregate employment growth controls for the cyclical position of the economy. When the economy expands, productivity growth may fall simply because the marginal worker is less productive. During those expansions, credit may also increase faster. Thus, controlling for the cyclical position ensures that the credit variable does not spuriously capture this effect.

11 Data on the credit gap are from Borio et al (2009). Moreover, for the sake of brevity, we only report estimations using five-year windows. Estimations using three-year windows are available upon request.

reflects the well-known view that inflation can lead to misallocations by introducing noise in the signals agents receive about relative prices (Lucas (1975)). If credit booms coincide with higher inflation then we may just be picking up this effect. Trade openness should be expected to boost productivity gains across sectors, including through reallocations towards sectors enjoying some comparative advantage. As already discussed, financial crises, which tend to be preceded by credit booms, are also known to generate output losses: the previous results may simply reflect their costs. Finally, the initial level of productivity is intended to capture the famous catch-up effect, ie the tendency for productivity growth to converge across countries.

Credit booms, productivity growth and its components — Table 4

	(i.a)	(ii.a)	(iii.a)	(i.b)	(ii.b)	(iii.b)
	Productivity growth	Common component	Allocation component	Productivity growth	Common component	Allocation component
Growth in private credit to GDP	–0.077**	–0.032	–0.045***			
	(0.0370)	*(0.0399)*	*(0.0170)*			
Average private credit to GDP gap				–0.0729***	–0.0318	–0.0412*
				(0.0131)	*(0.0549)*	*(0.0228)*
Employment growth	–0.372***	–0.514***	0.142**	–0.409***	–0.529***	0.120**
	(0.0796)	*(0.0931)*	*(0.0575)*	*(0.0665)*	*(0.0935)*	*(0.0579)*
Dummy for financial crisis	–0.013	–0.022	0.009	–0.0164	–0.0229	0.0065
	(0.0118)	(0.0142)	*(0.00708)*	*(0.0209)*	*(0.0145)*	*(0.00728)*
Initial private credit to GDP	0.023	0.026	–0.003	0.0588	0.0403	0.0186
	(0.0347)	*(0.0415)*	*(0.0216)*	*(0.0488)*	*(0.0396)*	*(0.0187)*
Government consumption to GDP	–0.674*	–0.705*	0.031	–0.587	–0.671	0.0836
	(0.344)	*(0.412)*	*(0.224)*	*(0.338)*	*(0.412)*	*(0.223)*
Openness to trade	0.096	0.154*	–0.058	0.107	0.158**	–0.0510
	(0.0732)	*(0.0795)*	*(0.0466)*	*(0.0551)*	*(0.0777)*	*(0.0475)*
CPI inflation	–0.075	0.125	–0.199*	–0.141	0.0958	–0.237**
	(0.165)	*(0.219)*	*(0.108)*	*(0.0741)*	*(0.216)*	*(0.116)*
Initial GDP per person employed (log of)	–0.271***	–0.222***	–0.049	–0.270***	–0.222***	–0.0480
	(0.0443)	*(0.0607)*	*(0.0407)*	*(0.0251)*	*(0.0618)*	*(0.0411)*
Observations	108	108	108	108	108	108
R-squared	0.864	0.854	0.695	0.858	0.854	0.681

Note: This table reports the estimated coefficient for independent variables reported in the first column, the dependent variable being aggregate productivity growth (columns (i.a) & (i.b)), the allocation component (columns (ii.a) & (ii.b)), the common component (columns (iii.a) & (iii.b)). Growth rates and averages are computed using 5-year windows. Estimation period: 1979-2009. All estimations include country and time fixed effects. Robust standard errors are in parentheses. Statistical significance at the 1%/5%/10% level respectively is indicated with ***/**/*.

The regression results using the growth rate in private credit to GDP as a measure of credit booms fully confirm the preliminary bivariate tests (Table 4). Based on 5-year windows, private credit to GDP growth is negatively correlated with aggregate productivity growth, and the result appears to be entirely driven by a strong and highly statistically significant relationship with the allocation component (column (iii.a)): there is no significant relationship between credit growth and the common component.[12]

Turning to the control variables, some interesting patterns emerge. There is little evidence of a financial deepening effect: the level of private credit to GDP does not seem to account for either aggregate productivity growth or its two components. On average, employment growth tends to coincide with lower aggregate productivity growth even as it goes hand-in-hand with productivity-enhancing reallocations: the common component dominates. And we can discard the view that labour reallocations are driven by changes in government expenditures. Government consumption does appear to dampen productivity growth, although the relationship is only weakly statistically significant, but no link is apparent with the allocation component.[13] The role of CPI inflation is consistent with priors: inflation correlates negatively and significantly with the allocation component of productivity growth, although there is no statistically significant relationship with productivity growth as a whole. Also as expected, openness to trade does co-vary positively with the common component of productivity growth, even if, as in the case of inflation, there is no statistically significant link with labour productivity growth as a whole. Finally, financial crises do not appear to affect productivity growth or any of its components in a statistically significant way.[14]

The regressions also shed light on the so-called catch-up effect. They indicate that the effect reflects almost exclusively the operation of the common component, since the correlation between the initial productivity level and the allocation component is not statistically significant. This implies that the allocation component is relatively more important in economies with higher productivity, because overall productivity growth will generally be lower there. If so, credit booms are likely to be more costly in advanced economies.

The conclusions are very similar if we use the credit gap as a proxy for credit booms, with some qualifications. In particular, in this case, the correlation with the allocation component is still apparent, but is statistically weaker. This difference probably reflects measurement errors: given the slow-moving trend, for current purposes the credit gap is a noisier measure of credit booms, particularly over short windows.

3.2 Decomposing the allocation component

The previous results highlight how labour reallocations during credit booms dampen productivity growth, but, strictly speaking, they are silent about the nature of the reallocations. Specifically, when the allocation component declines over time, is this

12 Results using a 3-year window are very similar, except that now there is some evidence of a statistically significant link also with the common component, albeit only at the 10% level. Possibly, over the shorter window, credit booms boost demand across all sectors, leading to a generalised increase in employment which leads to a productivity slowdown. But as the credit boom proceeds, the incidence across sectors becomes more differentiated so that the average effect fades out while labour reallocations keep taking place.

13 This hypothesis can be formally tested by computing productivity growth and its components, excluding the government sector.

14 This last result may sound surprising but it is important to remember that the regression controls for the position of the economy in the business cycle. In other words, the depressing effect of financial crises on productivity growth is already captured through the employment growth variable.

because, for a given distribution of sectoral productivity growth, employment grows more rapidly in low productivity growth sectors ("employment-driven")? Or is it because, for a given distribution of sectoral employment growth, productivity slows down in sectors with rapidly expanding employment ("productivity-driven")? Put differently, do changes over time in the allocation component reflect changes in the distribution of labour across sectors (as our use of the term "labour reallocation" suggests) or changes in the distribution of productivity gains across sectors?

To isolate these channels we carry out a variance decomposition exercise on the allocation component itself (Annex 1). We then run the same regressions (3) using each component of the variance decomposition as a dependent variable.

Decomposing the effect of credit booms on the allocation component — Table 5

	(i.a)	(ii.a)	(iii.a)	(iv.a)	(i.b)	(ii.b)	(iii.b)	(iv.b)
	Allocation component	Productivity-driven	Employment-driven	Jointly driven	Allocation component	Productivity-driven	Employment-driven	Jointly driven
Private credit to GDP growth	–0.0450***	0.0020	–0.0412***	–0.0058				
	(0.0170)	*(0.0073)*	*(0.0155)*	*(0.0055)*				
Average private credit to GDP gap					–0.0412*	0.0064	–0.0437**	–0.0039
					(0.0228)	*(0.0079)*	*(0.0210)*	*(0.0067)*
Employment growth	0.142**	–0.0489**	0.190***	6.52e–05	0.120**	–0.0485***	0.171***	–0.0029
	(0.0575)	*(0.0188)*	*(0.0536)*	*(0.0134)*	*(0.0579)*	*(0.0180)*	*(0.0543)*	*(0.0135)*
Dummy for financial crisis	0.0085	–0.0026	0.0119*	–0.0008	0.0065	–0.0029	0.0105	–0.0012
	(0.0071)	*(0.0023)*	*(0.0068)*	*(0.0014)*	*(0.00728)*	*(0.00221)*	*(0.00702)*	*(0.00149)*
Initial private credit to GDP	–0.0027	0.0212***	–0.0240	0.0001	0.0186	0.0213***	–0.0060	0.0032
	(0.0216)	*(0.0064)*	*(0.0210)*	*(0.0047)*	*(0.0187)*	*(0.0055)*	*(0.0171)*	*(0.0045)*
Government consumption to GDP	0.0312	–0.0010	0.0693	–0.0372	0.0836	0.0025	0.110	–0.0287
	(0.224)	*(0.0891)*	*(0.211)*	*(0.0585)*	*(0.223)*	*(0.0868)*	*(0.209)*	*(0.0572)*
Openness to trade	–0.0575	–0.0016	–0.0472	–0.0087	–0.0510	–0.0015	–0.0418	–0.0078
	(0.0466)	*(0.0161)*	*(0.0460)*	*(0.0092)*	*(0.0475)*	*(0.0159)*	*(0.0475)*	*(0.0089)*
CPI inflation	–0.199*	–0.162***	0.0176	–0.0553	–0.237**	–0.155***	–0.0226	–0.0587
	(0.108)	*(0.0491)*	*(0.0843)*	*(0.0375)*	*(0.116)*	*(0.0505)*	*(0.0901)*	*(0.0401)*
Initial GDP per person employed (log of)	–0.0490	0.0484***	–0.113***	0.0152	–0.0480	0.0496***	–0.113***	0.0157
	(0.0407)	*(0.0158)*	*(0.0341)*	*(0.0122)*	*(0.0411)*	*(0.0154)*	*(0.0364)*	*(0.0122)*
Observations	108	108	108	108	108	108	108	108
R-squared	0.695	0.852	0.653	0.692	0.681	0.853	0.644	0.687

Note: This table reports the estimated coefficient for independent variables reported in the first column, the dependent variable being the allocation component (columns (i.a) & (i.b)), the allocation component due to productivity shocks (columns (ii.a) & (ii.b)), the allocation component due to employment shocks (columns (iii.a) & (iii.b)) or the allocation component due to both productivity and employment shocks (columns (iv.a) & (iv.b)). These three last variables are computed based on decomposition (16) while the allocation component is computed using decomposition (1). Growth rates and averages are computed using 5-year windows. Estimation period: 1979-2009. All estimations include country and time fixed effects. Robust standard errors are in parentheses. Statistical significance at the 1%/5%/10% level respectively is indicated with ***/**/*.

The decomposition indeed confirms that the decline in the allocation component during credit booms overwhelmingly reflects shifts in employment towards low productivity growth sectors (Table 5). Specifically, the negative correlation between credit to GDP growth and the allocation component is explained almost exclusively by changes in industry-level employment growth rather than changes in size-weighted productivity growth across sectors: only the employment effect is statistically significant. In other words, credit booms do not appear to affect the sectoral distribution of productivity gains, turning potentially high productivity growth sectors into low productivity growth ones. Rather, they induce labour shifts into lower productivity growth sectors. Productivity in industries with rapid long-run productivity growth does not grow any more slowly during credit booms, but these industries attract relatively fewer workers. Table 5 shows that more than 90% of the effect of credit booms reflects these shifts in employment shares.

Switching to the credit to GDP gap provides very similar results. The negative correlation between credit booms and the allocation component remains largely unchanged, and still pertains to changes in the sectoral distribution of employment creation. The relative size of the effect is also very similar.

Are any specific sectors driving the results? To examine this, we proceed in two steps. First, instead of making use of the full set of sectors, we withdraw one of them at a time and consider the hypothetical economy made up of the correspondingly smaller set of sectors. Second, we re-compute decomposition (1) for that economy and run the previous set of regressions to check whether credit booms still correlate negatively with the allocation component.

The relationship between credit booms and the allocation component of productivity growth for different sector exclusions — Table 6

Sector withdrawn	None		AGRICULTURE		MINING		MANUFACTURING		UTILITIES	
	(i)	(ii)	(i)	(ii)	(i)	(ii)	(i)	(ii)	(i)	(ii)
	–0.0477***	–0.0450***	–0.0533***	–0.0462***	–0.0523***	–0.0273**	–0.0255	–0.0471*	–0.0555***	–0.0455**
	(0.0178)	(0.0170)	(0.0199)	(0.0152)	(0.0154)	(0.0127)	(0.0181)	(0.0251)	(0.0162)	(0.0207)
Sector withdrawn	**CONSTRUCTION**		**TRADE**		**TRANSPORT**		**FINANCE**		**OTHER SERVICES**	
	(i)	(ii)	(i)	(ii)	(i)	(ii)	(i)	(ii)	(i)	(ii)
	–0.0256	–0.0416**	–0.0543***	–0.0540***	–0.0463**	–0.0503**	–0.0657***	–0.0462***	–0.0406*	–0.0496**
	(0.0208)	(0.0204)	(0.0197)	(0.0190)	(0.0198)	(0.0192)	(0.0198)	(0.0168)	(0.0241)	(0.0201)

Note: This table reports the estimated coefficient and standard error for credit to GDP growth, the dependent variable being the allocation component of productivity growth. The dependent variable for each regression (i) & (ii) located in the same column is computed excluding the sector referred to in the row "Sector withdrawn". Estimations (i) include country and time fixed effects; estimations (ii) include the full set of controls used in specification (3) in addition to country and time fixed effects. Estimation period: 1979-2009. Robust standard errors are in parentheses. Statistical significance at the 1%/5%/10% level respectively is indicated with ***/**/*.

The results suggest that manufacturing and construction are the two sectors primarily responsible for the slowdown (Table 6). When either sector is withdrawn, the negative correlation goes away or at least weakens compared with the benchmark case. Interestingly, removing the financial sector does not affect our results.

Combining this result with the previous one, the conclusion is clear. Aggregate productivity slows down during credit booms primarily because employment expands more rapidly in the construction sector, which structurally features low productivity growth. And employment expands more slowly or contracts in manufacturing, which is structurally a high productivity growth sector.

3.3 Investigating causality

As a last robustness check, we investigate whether the evidence produced so far is simply a correlation or represents causality. But before we turn to the estimations designed to address this issue, it is worth noting that, in fact, the evidence so far does point to causality running from credit booms to productivity growth rather than the other way round.

Intuitively, reverse causality does not look plausible. It would imply that productivity slowdowns induce either financial intermediaries to supply more credit or firms and households to demand more of it. True, in the very short term one could imagine, say, households borrowing more to shield their consumption in the face of an unexpected slowdown in productivity and hence income. But such an effect should wash out over the relatively long windows we are considering. Moreover, credit tends to be pro-cyclical. And since we control for cyclical conditions through employment growth, the response of credit to the real economy is already largely filtered out. Finally, it is hard to see why credit would systematically react to productivity slowdowns driven by labour reallocations but not to those driven by the common component.

A first statistical safeguard against reverse causality is that in regressions (3) all right-hand-side variables are pre-determined with respect to the dependent variable, ie are measured at the beginning of the period. The exceptions are employment and credit growth, which are both measured over the same period.[15] Still, in order to lay to rest any residual doubts about the direction of causality even for these two variables, we instrument them. We do so with beginning-of-period values for the nominal long-term interest rate, the trade balance-to-GDP ratio, the current account balance-to-GDP ratio as well as the level and change in the financial liberalisation index constructed by Abiad et al (2008).

Table 7 provides the estimation results using this instrumental variable (IV) technique. Credit to GDP growth is the proxy for credit booms in the first four columns, and the average credit to GDP deviation from trend in the last four. As in previous tables, the common and the allocation components sum up to productivity growth and the dependent variable in estimations (iv.a) and (iv.b) is the part of the allocation component driven by changes in the sectoral distribution of employment, following the variance decomposition presented in section 3.2.

Estimation results confirm our previous findings. Indeed, the results become even starker. The estimated coefficient becomes larger in absolute value, suggesting that the OLS estimates may underestimate the effect of credit booms on productivity growth. For example, according to the OLS estimates, a 10 percentage point increase in private credit to GDP growth over 5 years reduces productivity growth by 0.8 percentage points over the same period. But according to the IV estimates, the slowdown in productivity is closer to 1.4 percentage points over five years, which amounts to dampening productivity growth by 0.25–0.30 percentage points per year. In addition, consistent with the OLS results, the IV estimates confirm that roughly 60% of the effect of credit booms on productivity reflects labour reallocations across

[15] In addition, the financial crisis dummy is measured over the same period as productivity growth. However, this variable proves in practice to have very little influence on the empirical results. We therefore take it out from the IV estimations to ensure all right-hand-side variables, except those we instrument, are pre-determined.

sectors. In other words, labour reallocation is quantitatively the main channel through which credit booms affect productivity. Moreover, these results hold pretty much unaltered if credit booms are measured with the credit gap.

Instrumenting credit booms and employment growth

Table 7

	(i.a)	(ii.a)	(iii.a)	(iv.a)	(i.b)	(ii.b)	(iii.b)	(iv.b)
	Productivity growth	Common component	Allocation component	Emp.-driven Allocation component	Productivity growth	Common component	Allocation component	Emp.-driven Allocation component
Private credit to GDP growth	–0.137***	–0.0545	–0.0822***	–0.0798***				
	(0.0464)	*(0.0581)*	*(0.0268)*	*(0.0309)*				
Average private credit to GDP gap					–0.188***	–0.0810	–0.107***	–0.102***
					(0.0685)	*(0.0750)*	*(0.0361)*	*(0.0395)*
Employment growth	–0.681***	–0.934***	0.253***	0.351***	–0.873***	–1.012***	0.139	0.241**
	(0.158)	*(0.175)*	*(0.0938)*	*(0.0957)*	*(0.187)*	*(0.178)*	*(0.102)*	*(0.0947)*
Initial private credit to GDP	0.0022	0.0387	–0.0365	–0.0497**	0.0472	0.0556*	–0.0084	–0.0219
	(0.0378)	*(0.0425)*	*(0.0223)*	*(0.0243)*	*(0.0337)*	*(0.0323)*	*(0.0177)*	*(0.0167)*
Government consumption to GDP	–0.841**	–0.737*	–0.104	–0.0195	–0.718*	–0.697*	–0.0210	0.0643
	(0.353)	*(0.401)*	*(0.217)*	*(0.225)*	*(0.386)*	*(0.385)*	*(0.227)*	*(0.217)*
Openness to trade	0.177**	0.259***	–0.0820*	–0.0900**	0.219**	0.276***	–0.0574	–0.0662
	(0.0896)	*(0.0884)*	*(0.0422)*	*(0.0388)*	*(0.100)*	*(0.0858)*	*(0.0534)*	*(0.0477)*
CPI inflation	–0.598***	–0.468**	–0.130	0.103	–0.787***	–0.556**	–0.231	0.0098
	(0.215)	*(0.214)*	*(0.141)*	*(0.122)*	*(0.274)*	*(0.246)*	*(0.161)*	*(0.132)*
Initial GDP per person employed (log of)	–0.155**	–0.0185	–0.136***	–0.164***	–0.129*	–0.0091	–0.120**	–0.148***
	(0.0668)	*(0.0711)*	*(0.0466)*	*(0.0480)*	*(0.0735)*	*(0.0692)*	*(0.0470)*	*(0.0449)*
J-stat	3.477	2.003	1.497	0.526	1.425	1.358	0.741	0.0599
p. value	*(0.324)*	*(0.572)*	*(0.683)*	*(0.913)*	*(0.700)*	*(0.715)*	*(0.863)*	*(0.996)*
LM-test	18.26	18.26	18.26	18.26	14.97	14.97	14.97	14.97
p. value	*(0.001)*	*(0.001)*	*(0.001)*	*(0.001)*	*(0.0048)*	*(0.0048)*	*(0.0048)*	*(0.0048)*
Observations	102	102	102	102	102	102	102	102
R-squared	0.491	0.503	0.140	0.133	0.346	0.466	0.048	0.138

Note: This table reports the estimated coefficients for independent variables reported in the first column from an IV regression where the dependent variable is aggregate productivity growth (columns (i.a) & (i.b)), the common component (columns (ii.a) & (ii.b)), the allocation component (columns (iii.a) & (iii.b)), the allocation component due to employment shocks ((columns (iv.a) & (iv.b))). The common and the allocation components are computed based on decomposition (1) while the employment-driven allocation component is computed using decomposition (16). Growth rates and averages are computed using 5-year windows. Employment growth and private credit to GDP growth or the average private credit to GDP gap are instrumented using the beginning-of-period values for the long-term interest rate, the short term-interest rate, the current account balance to GDP, the level and change in the financial liberalisation index (see Abiad et al (2008)). Estimation period: 1979-2009. All estimations include country and time fixed effects. Robust standard errors are in parentheses. Statistical significance at the 1%/5%/10% level respectively is indicated with ***/**/*.

4. Financial crises, labour reallocations and productivity growth

During credit booms labour tends to be reallocated into industries with low productivity growth. But what happens afterwards? Will misallocations persist and perhaps beget further misallocations? Or will the effects reverse? More importantly, how do these effects depend on the subsequent occurrence of a financial crisis?

To address these questions, and to ensure that the analysis is especially relevant for the current post-crisis period, we shift our focus somewhat from a panel of 3- or 5-year windows to a cross-section of economic downturns. We distinguish between "normal" downturns and those that coincide with financial crises. This is important because the results are likely to be different. For instance, Jorda et al (2013) find that recessions associated with financial crises are particularly deep and recoveries after downturns associated with credit booms particularly shallow. The impact of credit booms on the misallocation of labour documented in the previous section may provide a mechanism behind these findings.

4.1 Methodology

We start by identifying recessions, defined here as turning points in real GDP per working-age population, in our sample of 21 advanced economies.[16,17] Our panel thus includes 80 turning points (Table 8). Then, building on Jorda (2005), we consider for each country-recession year pair $(i;t)$, the subsequent path of labour productivity, ie $\{y_{i,t+h} / l_{i,t+h}; h > 0\}$, where $y_{i,t+h}$ and $l_{i,t+h}$ respectively denote GDP and the number of persons employed in country i, h years after the start of the year-t recession. Our dependent variable will thus be the percentage change in labour productivity relative to the start of the recession considering time horizons h running from 1 to 8 years, ie $\left\{\frac{y_{i,t+h} / l_{i,t+h}}{y_{i,t} / l_{i,t}}; h = 0,1,...,7,8\right\}$.

Two points concerning the sample construction are worth mentioning. First, since recessions are relatively rare events, we lengthen the sample by beginning in 1969, rather than in 1979 as done previously, in order maximise the number of recessions. Importantly, starting in 1979 does not change our findings, but it does significantly reduce the sample size, from 80 down to 59 episodes (the results are available on request).[18] Second, since our industry data stops in 2009, we rely on macroeconomic data to compute aggregate productivity. Critically, this allows us to include in the sample the most recent recessions, in particular those that hit in 2007-2008. This also means that estimations for the 7- and 8-year horizons – which use productivity figures for 2015 and 2016 – partly rely on forecasts of real GDP and employment.

16 We focus on real GDP per working-age population to filter for output fluctuations related to changes in demographics.

17 We impose two restrictions to identify recession dates. First, we require turning points in real GDP per working-age population to be local peaks, ie that the growth rate prior to the recession date be positive and the growth rate following the recession date be negative. Second, we exclude double dips, ie we require real GDP to working-age population for a given turning point to be higher than real GDP to working-age population at the previous turning point and lower than at the following turning point.

18 We could not have done a comprehensive analysis in the first part starting in 1969 because industry-level data are not available for a number of countries in the sample. Fortunately, however, they are available for all those that did experience a recession between 1969 and 1979.

The main explanatory variables we consider are the allocation and common components of productivity growth, as previously defined, alongside a financial crisis dummy, to test whether their impact depends on its occurrence. In our baseline specification we measure the productivity components over the 3-year pre-recession period, ie over $[t-3;t]$. We construct a financial crisis dummy that, for each country-peak pair $(i;t)$, equals one if a financial crisis occurs during the period from three years pre-peak and two years post-peak, ie $[t-3;t+2]$, and zero otherwise. Of the 80 turning points identified in our dataset, 22 turning points coincide with a financial crisis and 58 do not.[19] Unsurprisingly, the vast majority of the turning points that go hand-in-hand with financial crises refer to the Great Financial Crisis that hit in 2007–2008.

Recession dates

Table 8

	1969	1973	1974	1975	1976	1977	1979	1980	1981	1982	1983	1985	1986	1987	1989	1990	1991	1992	1997	2000	2001	2002	2004	2007	2008	Total
Australia		1			1				1			1				1										**5**
Austria								1			1							1							1c	**4**
Belgium			1		1			1										1							1c	**5**
Canada			1				1		1						1											**4**
Switzerland																					1				1c	**2**
Germany																					1				1c	**2**
Denmark		1					1						1					1						1c		**5**
Spain			1			1c											1							1c		**4**
Finland				1											1c										1	**3**
France			1					1		1								1				1		1c		**6**
United Kingdom							1									1								1c		**3**
Greece																								1c		**1**
Ireland																								1c		**1**
Italy			1					1c									1					1	1	1c		**6**
Japan		1															1		1c					1		**4**
Korea							1												1c						1	**3**
Netherlands			1					1													1				1c	**4**
Norway									1					1										1		**3**
Portugal			1					1		1c								1			1					**5**
Sweden					1			1							1c									1c		**4**
United States	1	1					1									1c				1				1c		**6**
Total	**1**	**4**	**7**	**1**	**3**	**1**	**4**	**7**	**3**	**2**	**1**	**1**	**1**	**1**	**3**	**3**	**3**	**5**	**1**	**1**	**4**	**2**	**1**	**11**	**7**	**80**

Note: The code 1 indicates a recession without a financial crisis, the code 1c a recession with a financial crisis.

The crisis dummy is included on its own and interacted with the productivity components. Including it on its own helps ensure that we do not spuriously attribute to the productivity components effects that belong to the crisis. Interacting the crisis

[19] There are two recessions out of 22 for which the financial crisis hits two years after real GDP to working-age population peaks, and one for which the financial crisis hits two years before the peak. In 19 out of 22, the financial crisis hits the same year as the peak or one year thereafter.

dummy with the productivity components allows us to test whether, in particular, the effect of labour reallocations on productivity differs depending on whether or not the economy experiences a crisis. This is important because financial crises may undermine the ability of the economy to correct past reallocations. Not least, tougher credit conditions could make adjustment harder, especially if banks' balance sheets are not promptly repaired, inducing, for instance, ever-greening (Peek and Rosengren (2005), Caballero et al (2008), Borio et al (2010)). But also more general rigidities in the credit extension process may be at work.

In addition, we include a set of control variables. A key one is the pre-peak credit boom proxy itself. Its coefficient filters out any effects of credit growth on subsequent productivity growth, over and above its impact working through the occurrence of a financial crisis and labour misallocations built up during the boom. It allows us to ask whether any such effects are material. We include our benchmark proxy – the growth in the credit-to-GDP ratio – and, where available, the credit gap. And for robustness we measure these over different pre-peak windows, not just 3 years. In addition, but of less interest, we also consider the growth rate in real GDP and that in employment up to 3 years prior to the peak.[20] This set of controls for the pre-turning point period is designed to eliminate alternative explanations for the results related to differences in background macroeconomic conditions. To test for these various possibilities, we estimate the following regression:

$$\frac{y_{i,t+h}/l_{i,t+h}}{y_{i,t}/l_{i,t}} = \alpha_{i,h} + \beta_h x_{i,t} + \left[\left(1-fc_{i,t}\right)\theta^0_{a,h} + fc_{i,t}\theta^1_{a,h}\right](alloc)_{i,t} + \left[\left(1-fc_{i,t}\right)\theta^0_{c,h} + fc_{i,t}\theta^1_{c,h}\right](com)_{i,t} + \varepsilon_{i,t,h} \tag{4}$$

where $\alpha_{i,h}$ is a set of country fixed effects, $x_{i,t}$ is the vector of control variables described above, $fc_{i,t}$ – the financial dummy variable – is equal to one if the recession starting in country i on year t is associated with a financial crisis and zero otherwise, and $\left(\beta_h;\theta^0_{a,h};\theta^1_{a,h};\theta^0_{c,h};\theta^1_{c,h}\right)$ are parameters to be estimated. Since we consider horizons h running from 1 to 8 years, we estimate each version of equation (4) 8 times, one for each different horizon h.

Next, we allow also the estimated coefficients for the control variables β_h to differ depending on whether the recession is associated with a financial crisis or not. The idea here is to test whether possible differences in the coefficients $\left(\theta^0_{a,h};\theta^1_{a,h};\theta^0_{c,h};\theta^1_{c,h}\right)$ are robust to relaxing the assumption that the other control variables affect the productivity path independently of whether a financial crisis hits or not. The corresponding regression becomes:

$$\frac{y_{i,t+h}/l_{i,t+h}}{y_{i,t}/l_{i,t}} = \alpha_{i,h} + \left[\left(1-fc_{i,t}\right)\beta^0_h + fc_{i,t}\beta^1_h\right]x_{i,t} + \left[\left(1-fc_{i,t}\right)\theta^0_{a,h} + fc_{i,t}\theta^1_{a,h}\right](alloc)_{i,t} + \left[\left(1-fc_{i,t}\right)\theta^0_{c,h} + fc_{i,t}\theta^1_{c,h}\right](com)_{i,t} + \varepsilon_{i,t,h} \tag{5}$$

[20] Here we consider two variants. In a first set of regressions, we include the 3-year growth rates prior to the peak, respectively denoted $y_{i,t}/y_{i,t-3}$ and $l_{i,t}/l_{i,t-3}$. In the second set of regressions -those reported below-, we use the year-on-year growth rates up to 3 years prior the peak for output $\left\{y_{i,t-j}/y_{i,t-j-1}\right\}_{0\le j\le 2}$ and employment $\left\{l_{i,t-j}/l_{i,t-j-1}\right\}_{0\le j\le 2}$ respectively.

where β_h^0 and β_h^1 are row vectors of coefficients to estimate, other notation being unchanged.

4.2 Empirical results

We start with estimation results for specification (4) (Table 9).[21] There are four main findings.

First, financial crises have persistent direct negative effects on the subsequent path of aggregate labour productivity. This finding largely confirms previous findings in the literature, which highlight the costs of crises, although the present one points to a persistent impact on growth.

Second, and more important for our analysis, the occurrence of a crisis greatly amplifies the impact of previous misallocations. The interaction between the crisis dummy and the allocation component is statistically highly significant and increases as the horizon lengthens. True, misallocations during the boom also reduce post-recession productivity growth if there is no crisis, but the effect is considerably smaller and is not statistically significant for intermediate horizons.

Third, a crisis also amplifies the effect of the common component of productivity growth during the boom years, but to a smaller extent. In addition, the overall size of the dampening effect on productivity is smaller and builds up only gradually.

Finally, credit growth during the boom does not appear to have any additional effects on subsequent productivity growth. The statistical insignificance of the various coefficients suggests that the impact operates through misallocations during the boom and the incidence of a crisis.

The bottom line is clear. The occurrence of a financial crisis amplifies the impact of pre-peak productivity growth and its components. Moreover, it affects their relative incidence. If a crisis does occur, the productivity path is much more sensitive to the allocation component than to the common component. But when it does not, the impacts are more similar: the F-tests on the last row of Table 9 show that the impact of the allocation and common components are not statistically different from each other.

21 For simplicity, in order to keep estimation tables tractable, we do not report estimated parameters for control variables except for credit growth, which is of special interest.

Labour reallocation, credit expansion, financial crises and subsequent productivity growth

Dependent variable: aggregate labour productivity growth — Table 9

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Allocation component × FC	0.885**	2.297***	2.393***	2.998***	3.971***	4.562***	5.026***	5.678***
	(0.377)	*(0.612)*	*(0.819)*	*(1.071)*	*(1.176)*	*(1.250)*	*(1.348)*	*(1.510)*
Allocation component × NFC	0.252**	0.449***	0.360	0.303	0.431	0.606*	0.618*	0.732*
	(0.103)	*(0.151)*	*(0.243)*	*(0.306)*	*(0.300)*	*(0.303)*	*(0.318)*	*(0.371)*
Common component × FC	0.310	0.735**	0.886*	1.237**	1.692***	1.974***	2.237***	2.453***
	(0.224)	*(0.331)*	*(0.441)*	*(0.542)*	*(0.510)*	*(0.528)*	*(0.569)*	*(0.640)*
Common component × NFC	0.0938	0.359**	0.362*	0.474*	0.632**	0.814***	1.062***	1.315***
	(0.109)	*(0.169)*	*(0.209)*	*(0.265)*	*(0.282)*	*(0.291)*	*(0.314)*	*(0.362)*
FC dummy	–2.489**	–6.208***	–6.495**	–8.707**	–10.95***	–12.09***	–12.17***	–12.30***
	(1.058)	*(2.053)*	*(2.862)*	*(3.571)*	*(3.616)*	*(3.742)*	*(3.983)*	*(4.377)*
Credit to GDP growth	0.540	2.512	4.473	5.902	10.30	11.82*	7.795	7.347
	(2.588)	*(3.642)*	*(5.385)*	*(6.899)*	*(6.690)*	*(6.980)*	*(8.188)*	*(9.084)*
Observations	80	80	80	80	80	80	80	80
R-squared	0.589	0.756	0.742	0.733	0.742	0.731	0.741	0.749
H0: Alloc × FC = Alloc × NFC	0.118	0.006	0.022	0.018	0.005	0.003	0.002	0.002
H0: Com × FC = Com × NFC	0.199	0.112	0.105	0.051	0.006	0.003	0.005	0.016
H0: Alloc × FC = Com × FC	0.129	0.001	0.013	0.026	0.017	0.013	0.011	0.010
H0: Alloc × NFC = Com × NFC	0.114	0.557	0.993	0.556	0.448	0.466	0.184	0.103

Note: This table reports the estimated coefficients for each of the independent variables reported in the first column in the regression using as dependent variable the percentage deviation of labour productivity n years after the start of the recession, n being reported in parentheses on the second row. Allocation (Common) refers to the allocation (common) component of labour productivity growth as defined in equation (1) in section 2 and measured over the 3-year period prior to the start of the recession. FC dummy is equal to one if a financial crisis hits between 3 years before and 2 years after the start of the recession and equal to zero otherwise. Credit to GDP growth is measured over the 3-year period prior to the start of the recession. A variable name followed by the sign × FC (× NFC) indicates an interaction term which is equal to the variable when the financial crisis dummy is equal to one (equal to zero) and equal to zero (equal to the variable) otherwise. All regressions include the following unreported control variables: all real GDP and employment y-o-y growth rates for the 3-year period prior to the start of the recession as well as country fixed effects. Estimation period 1969-2016 (see the main text for a detailed explanation). Robust standard errors are in parentheses. Statistical significance at the 1%/5%/10% level respectively is indicated with ***/**/*. The four last rows report the p. value attached to the F-test where the null hypothesis H0 is that the estimated coefficients for the two reported variables are identical.

We next estimate specification (5), allowing, in particular, also credit to GDP growth to affect differently the path of subsequent productivity depending on the occurrence of a financial crisis (Table 10). The previous conclusions are broadly unchanged. Pre-peak credit to GDP growth has no discernible impact on the subsequent productivity path if no crisis occurs. Things are only marginally different if it does: in this case, strong previous credit to GDP growth actually has some statistically significant positive effect, but only in years 5 and 6 after the turning point.

Labour reallocation, sector-level productivity growth, credit expansion and financial crises

Dependent variable: aggregate labour productivity growth — Table 10

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Allocation component × FC	0.875**	2.265***	2.454***	3.143***	4.236***	4.808***	5.222***	5.806***
	(0.375)	*(0.626)*	*(0.803)*	*(1.011)*	*(1.064)*	*(1.173)*	*(1.289)*	*(1.479)*
Allocation component × NFC	0.258**	0.470***	0.322	0.212	0.266	0.451	0.495	0.652*
	(0.0974)	*(0.156)*	*(0.253)*	*(0.316)*	*(0.301)*	*(0.307)*	*(0.325)*	*(0.383)*
Common component × FC	0.298	0.693**	0.962**	1.419**	2.024***	2.284***	2.484***	2.614***
	(0.249)	*(0.338)*	*(0.454)*	*(0.537)*	*(0.479)*	*(0.489)*	*(0.529)*	*(0.599)*
Common component × NFC	0.0933	0.357**	0.366*	0.483*	0.648**	0.829***	1.074***	1.323***
	(0.111)	*(0.171)*	*(0.208)*	*(0.260)*	*(0.262)*	*(0.273)*	*(0.303)*	*(0.357)*
FC dummy	–2.332*	–5.679**	–7.475**	–11.06***	–15.23***	–16.08***	–15.34***	–14.37***
	(1.225)	*(2.283)*	*(3.000)*	*(3.431)*	*(3.404)*	*(3.705)*	*(4.048)*	*(4.516)*
Credit to GDP growth x FC	–0.0902	0.386	8.408	15.34	27.47***	27.85**	20.53	15.65
	(4.906)	*(5.911)*	*(7.377)*	*(9.420)*	*(9.727)*	*(10.94)*	*(12.68)*	*(14.37)*
Credit to GDP growth × NFC	0.823	3.466	2.708	1.669	2.598	4.626	2.081	3.621
	(2.534)	*(4.050)*	*(5.643)*	*(7.106)*	*(6.968)*	*(7.396)*	*(8.871)*	*(9.924)*
Observations	80	80	80	80	80	80	80	80
R-squared	0.589	0.757	0.744	0.741	0.761	0.745	0.748	0.751
H0: Alloc × FC = Alloc × NFC	0.117	0.009	0.015	0.007	0.001	0.001	0.001	0.001
H0: Com × FC = Com × NFC	0.278	0.169	0.082	0.0192	0.000	0.000	0.000	0.004
H0: Alloc × FC = Com × FC	0.135	0.001	0.0140	0.026	0.011	0.008	0.008	0.008
H0: Alloc × NFC = Com × NFC	0.118	0.478	0.861	0.363	0.153	0.193	0.087	0.065

Note: This table reports the estimated coefficients for each of the independent variables reported in the first column in the regression using as dependent variable the percentage deviation of labour productivity n years after the start of the recession, n being reported in parentheses on the second row. Allocation (Common) refers to the allocation (common) component of labour productivity growth as defined in equation (1) in section 2 and measured over the 3-year period prior to the start of the recession. FC dummy is equal to one if a financial crisis hits between 3 years before and 2 years after the start of the recession and equal to zero otherwise. Credit to GDP growth is measured over the 3-year period prior to the start of the recession. A variable name followed by the sign × FC (× NFC) indicates an interaction term which is equal to the variable when the financial crisis dummy is equal to one (equal to zero) and equal to zero (equal to the variable) otherwise. All regressions include the following unreported control variables: all real GDP and employment y-o-y growth rates for the 3-year period prior to the start of the recession as well as country fixed effects. Estimation period 1969-2016 (see the main text for a detailed explanation). Robust standard errors are in parentheses. Statistical significance at the 1%/5%/10% level respectively is indicated with ***/**/*. The four last rows report the p. value attached to the F-test where the null hypothesis H0 is that the estimated coefficients for the two reported variables are identical.

Finally, we run two robustness checks. First, we re-run estimation (5) using independent variables computed over a 4-year window prior to the peak. Results reported in Table 11 are qualitatively identical to those in Table 10. In particular, when a financial crisis hits, the allocation and the common components of productivity growth have a much larger effect on subsequent labour productivity, with the sensitivity to the allocation component increasing disproportionately more. Again, credit to GDP growth – also computed over a 4-year window – does not have any consistently significant effect on subsequent labour productivity.

Labour reallocation, sector-level productivity growth, credit expansion and financial crises

Dependent variable: aggregate labour productivity growth — Table 11

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Allocation × FC	0.7385*	1.623**	1.664**	1.976**	2.553**	2.842**	2.898**	3.195**
	(0.384)	*(0.621)*	*(0.737)*	*(0.884)*	*(0.993)*	*(1.058)*	*(1.115)*	*(1.291)*
Allocation × NFC	0.197*	0.355**	0.224	0.122	0.162	0.311	0.289	0.382
	(0.100)	*(0.172)*	*(0.258)*	*(0.312)*	*(0.305)*	*(0.319)*	*(0.351)*	*(0.424)*
Common × FC	0.277	0.543	0.772*	1.048**	1.399***	1.544***	1.526***	1.579**
	(0.185)	*(0.332)*	*(0.428)*	*(0.508)*	*(0.494)*	*(0.517)*	*(0.547)*	*(0.622)*
Common × NFC	0.0872	0.290	0.297	0.353	0.440	0.563*	0.643*	0.797*
	(0.101)	*(0.183)*	*(0.230)*	*(0.286)*	*(0.295)*	*(0.312)*	*(0.336)*	*(0.400)*
FC dummy	–2.979*	–5.772*	–7.462**	–10.67**	–14.16***	–14.67***	–13.23**	–12.05**
	(1.683)	*(2.968)*	*(3.632)*	*(4.208)*	*(4.601)*	*(4.993)*	*(5.242)*	*(5.750)*
Credit to GDP growth x FC	1.076	0.999	7.473	12.91	21.72**	22.06*	14.82	10.71
	(4.400)	*(5.595)*	*(6.431)*	*(8.740)*	*(10.63)*	*(12.24)*	*(13.86)*	*(15.62)*
Credit to GDP growth × NFC	0.0349	2.592	1.348	–0.561	–0.586	–0.226	–4.284	–3.878
	(2.088)	*(3.695)*	*(5.269)*	*(6.605)*	*(6.638)*	*(6.679)*	*(7.418)*	*(8.301)*
Observations	79	79	79	79	79	79	79	79
R-squared	0.609	0.730	0.738	0.729	0.730	0.708	0.708	0.708
H0: Alloc × FC = Alloc × NFC	0.185	0.053	0.074	0.052	0.025	0.024	0.026	0.036
H0: Com × FC = Com × NFC	0.123	0.239	0.090	0.032	0.004	0.005	0.016	0.054
H0: Alloc × FC = Com × FC	0.202	0.013	0.065	0.116	0.100	0.088	0.089	0.092
H0: Alloc × NFC = Com × NFC	0.269	0.685	0.768	0.442	0.329	0.394	0.29	0.275

Note: This table reports the estimated coefficients for each of the independent variables reported in the first column in the regression using as dependent variable the percentage deviation of labour productivity n years after the start of the recession, n being reported in parentheses on the second row. Allocation (Common) refers to the allocation (common) component of labour productivity growth as defined in equation (1) in section 2 and measured over the 4-year period prior to the start of the recession. FC dummy is equal to one if a financial crisis hits between 3 years before and 2 years after the start of the recession and equal to zero otherwise. Credit to GDP growth is measured over the 4-year period prior to the start of the recession. A variable name followed by the sign × FC (× NFC) indicates an interaction term which is equal to the variable when the financial crisis dummy is equal to one (equal to zero) and equal to zero (equal to the variable) otherwise. All regressions include the following unreported control variables: all real GDP and employment y-o-y growth rates for the 4-year period prior to the start of the recession as well as country fixed effects. Estimation period 1969-2016 (see the main text for a detailed explanation). Robust standard errors are in parentheses. Statistical significance at the 1%/5%/10% level respectively is indicated with ***/**/*. The four last rows report the p. value attached to the F-test where the null hypothesis H0 is that the estimated coefficients for the two reported variables are identical.

The second robustness check consists in re-estimating regression (5) using the credit gap rather than private credit to GDP growth as an indicator of the credit boom (Table 12). The main conclusions for the productivity components are unchanged. Interestingly, the estimated sizes of the coefficients for the two components are also very similar to those estimated previously.

Labour reallocation, sector-level productivity growth, credit expansion and financial crises

Dependent variable: aggregate labour productivity growth Table 12

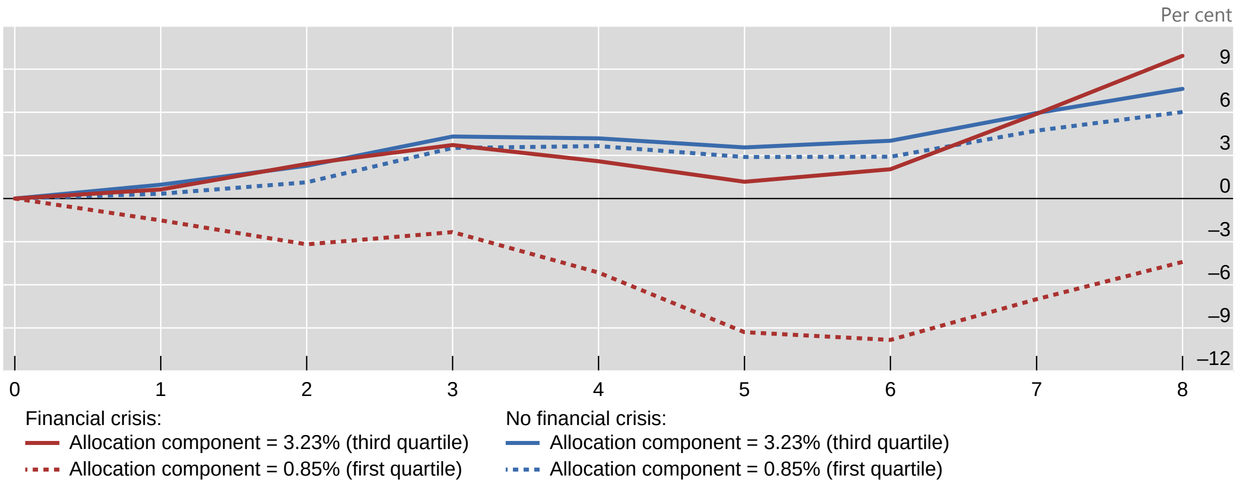
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Allocation × FC	1.067***	2.453***	2.606***	3.382***	4.421***	4.971***	5.394***	5.914***
	(0.362)	(0.587)	*(0.720)*	*(0.841)*	*(0.951)*	*(1.086)*	(1.160)	*(1.360)*
Allocation × NFC	0.216**	0.425**	0.266	0.151	0.213	0.388	0.435	0.565
	(0.103)	*(0.162)*	*(0.235)*	*(0.284)*	*(0.260)*	*(0.271)*	*(0.295)*	*(0.352)*
Common × FC	0.507**	0.906**	1.195**	1.762***	2.372***	2.628***	2.794***	2.879***
	(0.225)	*(0.362)*	*(0.479)*	*(0.529)*	*(0.483)*	*(0.514)*	*(0.539)*	*(0.636)*
Common × NFC	0.134	0.409**	0.385**	0.518**	0.666***	0.843***	1.084***	1.299***
	(0.106)	*(0.163)*	*(0.189)*	*(0.227)*	*(0.233)*	*(0.253)*	*(0.277)*	*(0.333)*
FC dummy	–3.722***	–7.183***	–8.686***	–12.40***	–15.86***	–16.83***	–16.23***	–15.61***
	(1.074)	*(2.345)*	*(3.090)*	*(3.281)*	*(3.197)*	*(3.415)*	*(3.604)*	*(4.141)*
Credit to GDP gap x FC	6.559*	7.015	14.93*	23.67**	33.75***	34.31***	27.30**	23.20
	(3.584)	*(6.467)*	*(8.038)*	*(9.585)*	*(8.892)*	*(9.946)*	*(11.67)*	*(13.92)*
Credit to GDP gap × NFC	0.158	4.016	–0.593	–2.127	–2.542	–0.975	–3.484	–4.900
	(2.189)	*(4.295)*	*(5.738)*	*(7.287)*	*(6.506)*	*(6.639)*	*(6.919)*	*(7.767)*
Observations	81	81	81	81	81	81	81	81
R-squared	0.609	0.765	0.756	0.758	0.775	0.755	0.757	0.758
H0: Alloc × FC = Alloc × NFC	0.029	0.0025	0.005	0.001	0.000	0.000	0.000	0.000
H0: Com × FC = Com × NFC	0.036	0.077	0.030	0.003	0.000	0.000	0.000	0.001
H0: Alloc × FC = Com × FC	0.138	0.001	0.007	0.013	0.008	0.007	0.006	0.007
H0: Alloc × NFC = Com × NFC	0.410	0.925	0.650	0.219	0.084	0.117	0.048	0.038

Note: This table reports the estimated coefficients for each of the independent variables reported in the first column in the regression using as dependent variable the percentage deviation of labour productivity n years after the start of the recession, n being reported in parentheses on the second row. Allocation (Common) refers to the allocation (common) component of labour productivity growth as defined in equation (1) in section 2 and measured over the 3 year period prior to the start of the recession. FC dummy is equal to one if a financial crisis hits between 3 years before and 2 years after the start of the recession and equal to zero otherwise. Credit to GDP gap is the average percentage deviation of credit to GDP from trend measured over the 3 year period prior to the start of the recession. A variable name followed by the sign × FC (× NFC) indicates an interaction term which is equal to the variable when the financial crisis dummy is equal to one (equal to zero) and equal to zero (equal to the variable) otherwise. All regressions include the following unreported control variables: all real GDP and employment y-o-y growth rates for the 3 year period prior to the start of the recession as well as country fixed effects. Estimation period 1969-2016 (see the main text for a detailed explanation). Robust standard errors are in parentheses. Statistical significance at the 1%/5%/10% respectively indicated with ***/**/*. The four last rows report the p. value attached to the F-test where the null hypothesis H0 is that the estimated coefficients for the two reported variables are identical.

To wrap-up these results, we simulate the estimated path for productivity based on specification (5). To do so, we consider two different assumptions. The first relates to the occurrence of a financial crisis and the second to the allocation component, which can be either "high" (relatively small misallocations having little effect on productivity during the expansion) or "low" (large misallocations causing more damage).[22] We therefore end up with four different scenarios and simulate each productivity path.

Labour reallocation, financial crises and the path of productivity

Graph 3



Simulations based on local projection regressions of the percentage deviation of labour productivity from the recession year, estimated in Table 10. The independent variables include the allocation and the common components of productivity growth over the three-year period prior to the start of the recession. Effects are shown separately for recessions associated with a financial crisis (red lines) and recessions not associated with a financial crisis (blue lines). Solid lines show the projection of labour productivity conditional on a positive allocation component contribution of 3.23 percentage points over three years prior to the recession. Dashed lines are conditional on a 0.85 percentage point contribution of the allocation component over three years prior to the recession.

Source: Authors' calculations.

In Graph 3, the red lines refer to paths with a crisis and the blue ones to those without a crisis. In turn, continuous lines refer to paths associated with a relatively high allocation component and dashed lines to paths associated with a low one. Three conclusions stand out.

First, in the absence of a crisis, the allocation component makes a modest difference for the subsequent evolution of productivity. The gap between the solid and the dashed blue lines remains below one percentage point during the first six years after the start of the recession and then rises to 2 percentage points 2 years later.

Second, by contrast, when a financial crisis hits, the allocation component matters much more. The difference between the red solid and the red dashed lines is around 5 percentage points 3 years after the peak and reaches more than 11 percentage points after 6 years.

Finally, the drag on productivity due to a financial crisis is much larger when these labour misallocations have been large during the expansion, ie the allocation component prior to the recession is low. The dashed red line is much lower than the

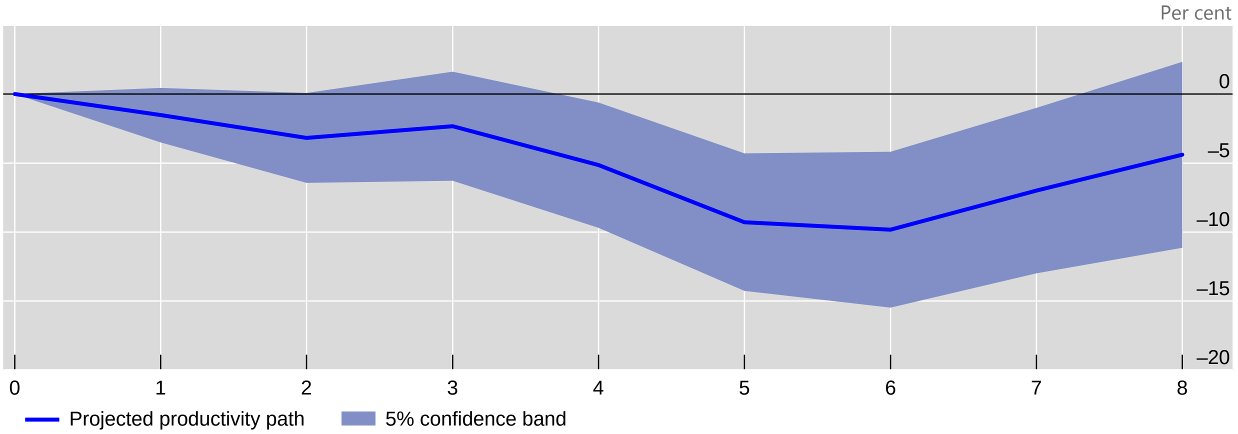
[22] We consider the sample distribution for the allocation component and identify the case of a low allocation component (high allocation component) as equal to the value of the 25th percentile (75th percentile). Interestingly, the moments of the full sample and conditional distributions for the allocation component are very similar. Thus, conditioning or not on the occurrence of a financial crisis does not change significantly the value of the distribution quartiles.

rest. Put differently, it is the combination of a financial crisis with past misallocations that generates the largest and most long-lasting damage to productivity.

As a confirmation of this finding, Graph 4 shows the confidence bands around the productivity path for an economy facing a financial crisis and inheriting a relatively low allocation component prior to the recession. It indicates that this configuration can lead to long-lasting productivity stagnation, possibly recovering the productivity level at the start of the recession only some eight years after.

Stagnation following a financial crisis and a weak labour reallocation contribution to past productivity growth

Graph 4



Simulations based on local projection regressions of the percentage deviation of labour productivity from the recession year, estimated in Table 10. The independent variables include the allocation and the common components of productivity growth over the three-year period prior to the start of the recession. Solid blue line shows the projection of labour productivity conditional on a positive allocation component contribution of 0.85 percentage point over three years prior to the recession. The blue area around the solid blue line represents the 5% confidence interval around the projected productivity path.

Source: Authors' calculations.

5. Conclusion

In this paper we have investigated the relationship between credit booms, productivity growth, labour reallocations and financial crises. We have identified two new possible stylised facts. First, credit booms tend to undermine productivity growth as they occur, largely through labour reallocations towards lower productivity growth sectors. Second, labour reallocations that occur during a boom, and during economic expansions more generally, have a much larger effect on subsequent productivity if a crisis follows. This effect dominates that of other variables, including the non-allocational (common) component of productivity growth. In other words, this second stylised fact is consistent with the view that when economic conditions become more hostile, misallocations beget misallocations; they have a long reach. These findings, based on a large sample of over twenty advanced economies and over forty years, are robust to different definitions of credit expansion and to the inclusion of various controls.

These findings have broader implications for the current policy debate and for macroeconomics more generally.

First, they shed new light on the secular stagnation hypothesis (Summers (2014)), according to which the United States was facing a structural deficiency of aggregate demand even before the crisis. Our findings suggest a different mechanism, in which the slow recovery after the Great Financial Crisis is the result of a major financial boom and bust, which has left long-lasting scars on the economic tissue (eg BIS (2014), Rogoff (2015)). More specifically, they suggest that what some see as a comparatively disappointing US growth performance in the pre-crisis years, *despite* a strong financial boom, was actually disappointing, in part, precisely *because* of the boom. And so has been the post-crisis weak productivity growth.

Second, the findings suggest that when considering the macroeconomic implications of financial booms and busts it is important to go beyond the current focus on aggregate demand effects. True, credit growth during a boom boosts aggregate demand and output. And deleveraging, balance sheet repair and tighter credit constraints depress spending during a financial bust. But supply-side effects during the boom and the bust, operating in particular through resource misallocations, are also important. Thus, our findings help explain the usefulness of financial cycle proxies, notably credit and property prices, in the measurement of potential output in real time during the boom-proxies that, in contrast to traditional methods sometimes based on inflation, could indeed identify that output was running ahead of potential in the pre-crisis years (Borio et al (2013)). And they also provide a complementary explanation for hysteresis effects – one linked to the allocation of credit and real resources rather than simply to protracted aggregate demand weakness, although the two may of course interact. All this highlights the importance of supply-side policies.

Third, the findings enrich our understanding of the medium- to long-run effects of monetary policy and of its effectiveness in addressing financial busts (Borio (2015)). If loose monetary policy contributes to credit booms and these booms have long-lasting, if not permanent, effects on output and productivity, including through factor reallocations, once the bust occurs, then it is not reasonable to think of money as neutral over long-term policy horizons. This is at least the case if a financial crisis erupts. After all, financial booms and busts linked to crises have had a length of between 16 and 20 years (eg Drehmann et al (2011)), and our results confirm that misallocations take time to develop and have very long-lasting effects. Nor is it surprising if monetary policy may not be particularly effective in addressing financial busts. This is not just because its force is dampened by debt overhangs and a broken banking system – the usual "pushing-on-a-string" argument. It may also be because loose monetary policy is a blunt tool to correct the resource misallocations that developed during the previous expansion, as it was a factor contributing to them in the first place.

Finally, the findings underline the need to use a wider range of models in monetary policy analysis. In policy formulation, all too often the conclusions are based on the standard "one-good" benchmark model – or on models that behave *as if* there was only one good. Models should be able to accommodate the implications of costly sectoral shifts, well beyond those linked to the time-honoured distinction between tradables and nontradables. Otherwise there is a risk of throwing out the baby with the bathwater.

Our paper is fundamentally empirical and about stylised facts. We have not developed a formal model to account for them. Even so, many possible mechanisms come to mind. These involve, during credit booms, the different incidence of credit expansion across sectors, not least owing to collateral characteristics. And they involve, during busts, the interaction between financial crises, the scarcity of credit, slow balance sheets repair and the need to reverse the previous resource misallocations linked to temporarily bloated sectors. These questions deserve deeper scrutiny and will be the focus of future research.

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Annex

A.1 Labour reallocations and productivity growth

As a matter of identities, it is possible to isolate the contribution of labour reallocations to productivity growth. Aggregate output y and aggregate employment l can be written as the sums of sector-level output y_s and employment l_s:

$$y = \sum_s y_s \text{ and } l = \sum_s l_s \tag{6}$$

Assuming the economy is composed of S different sectors and denoting by $\overline{x}$ the simple average for variable x_s across all sectors ($\overline{y} = y / S$; $\overline{l} = l / S$), aggregate productivity y / l can be written as the sum of two terms:

$$\frac{y}{l} = \frac{1}{S}\sum_s \left(\frac{l_s}{l / S}\right) . \left(\frac{y_s}{l_s}\right) = \overline{y_s / l_s} + cov\left(\frac{y_s}{l_s}; \frac{l_s}{\overline{l}}\right) \tag{7}$$

The first term represents the unweighted average productivity of all sectors in the economy while the second term measures the covariance between a sector's labour productivity and its share in total employment. This variance is positive if sectors with higher productivity account for a large share of total employment, making aggregate productivity y / l higher than the unweighted average sector-level productivity $\overline{y_s / l_s}$.

Building on the decomposition in expression (7) and denoting sector s share in total output as $\alpha_s = y_s / \overline{y}$, it is possible to write the growth rate of real output $\Delta y / y$ as the sum of two terms:

$$1 + \frac{\Delta y}{y} = \frac{1}{S}\sum_s \alpha_s \left(1 + \frac{\Delta y_s}{y_s}\right) = 1 + \overline{\frac{\Delta y_s}{y_s}} + cov\left(\frac{\Delta y_s}{y_s}; \alpha_s\right) \tag{8}$$

The first term, $\overline{\Delta y_s / y_s}$, represents the unweighted average of sector-level output growth; the second, $cov\left(\frac{\Delta y_s}{y_s}; \alpha_s\right)$, represents the covariance between a sector's real output growth and its share in total output. Based on this decomposition, aggregate labour productivity growth can be written as

$$1 + \frac{\Delta(y / l)}{y / l} = \frac{1}{S}\sum_s \alpha_s \left(1 + \frac{\Delta(y_s / l)}{y_s / l}\right) = 1 + \overline{\frac{\Delta(y_s / l)}{y_s / l}} + cov\left(\frac{\Delta(y_s / l)}{y_s / l}; \alpha_s\right) \tag{9}$$

We now write the growth rate of real sectoral output to total employment $\Delta(y_s / l) / (y_s / l)$ as the product of two terms: one depends on the growth rate of the sector-level employment share $\Delta(l_s / l) / (l_s / l)$ and the other on the growth rate of sector-level labour productivity $\Delta(y_s / l_s) / (y_s / l_s)$:

$$1+\frac{\Delta(y_s/l)}{y_s/l}=\frac{1+\frac{\Delta l_s}{l_s}}{1+\frac{\Delta l}{l}}\frac{1+\frac{\Delta y_s}{y_s}}{1+\frac{\Delta l_s}{l_s}}=\left(1+\frac{\Delta(l_s/l)}{l_s/l}\right)\left(1+\frac{\Delta(y_s/l_s)}{y_s/l_s}\right) \tag{10}$$

Then, using (9) and (10), aggregate real productivity growth can be written as

$$1+\frac{\Delta(y/l)}{y/l}=\overline{\left(1+\frac{\Delta(l_s/l)}{l_s/l}\right)\left(1+\frac{\Delta(y_s/l_s)}{y_s/l_s}\right)}+cov\left(\left(1+\frac{\Delta(l_s/l)}{l_s/l}\right)\left(1+\frac{\Delta(y_s/l_s)}{y_s/l_s}\right);\alpha_s\right) \tag{11}$$

We can now simplify this expression by decomposing each of the RHS terms of expression (11). Using the definition of a covariance, the first term, which measures the growth rate of sectoral output to total employment, can be written as:

$$\overline{\left(1+\frac{\Delta(l_s/l)}{l_s/l}\right)\left(1+\frac{\Delta(y_s/l)}{y_s/l}\right)}=\left(1+\overline{\frac{\Delta(l_s/l)}{l_s/l}}\right)\left(1+\overline{\frac{\Delta(y_s/l_s)}{y_s/l_s}}\right)+cov\left(\frac{\Delta(l_s/l)}{l_s/l};\frac{\Delta(y_s/l_s)}{y_s/l_s}\right) \tag{12}$$

In turn, the second term of expression (11) measures the covariance between the sector-level relative output size α_s, on the one hand, and the product of the growth rate of the sector-level employment share $\Delta(l_s/l)/(l_s/l)$ and the growth rate of sector-level labour productivity $\Delta(y_s/l)/(y_s/l)$, on the other hand. This can be written as:

$$\begin{aligned}cov\left(\left(1+\frac{\Delta(l_s/l)}{l_s/l}\right)\left(1+\frac{\Delta(y_s/l_s)}{y_s/l_s}\right);\alpha_s\right)=\left(1+\overline{\frac{\Delta(l_s/l)}{l_s/l}}\right)cov\left(\frac{\Delta(y_s/l_s)}{y_s/l_s};\alpha_s\right)+\\ cov\left(\frac{\Delta(l_s/l)}{l_s/l};(\alpha_s-1)\left(1+\frac{\Delta(y_s/l_s)}{y_s/l_s}\right)\right)\end{aligned} \tag{13}$$

As a result, using expressions (11), (12) and (13), the growth rate of aggregate real labour productivity becomes the sum of three terms:

$$\begin{aligned}1+\frac{\Delta(y/l)}{y/l}=\left(1+\overline{\frac{\Delta(l_s/l)}{l_s/l}}\right)\left(1+\overline{\frac{\Delta(y_s/l_s)}{y_s/l_s}}\right)+\\ \left(1+\overline{\frac{\Delta(l_s/l)}{l_s/l}}\right)cov\left(\frac{\Delta(y_s/l_s)}{y_s/l_s};\alpha_s\right)+cov\left(\frac{\Delta(l_s/l)}{l_s/l};\left(1+\frac{\Delta(y_s/l_s)}{y_s/l_s}\right)\alpha_s\right)\end{aligned} \tag{14}$$

Combining the first and second terms on the right-hand side of (14), we can further simplify the decomposition of aggregate labour productivity growth as

$$1+\frac{\Delta(y/l)}{y/l}=\underbrace{\left[1+\overline{\frac{\Delta(l_s/l)}{l_s/l}}\right]\left[1+\overline{\frac{\Delta(y_s/l_s)}{y_s/l_s}\alpha_s}\right]}_{\text{common component}}+\underbrace{cov\left(\frac{\Delta(l_s/l)}{l_s/l};\left(1+\frac{\Delta(y_s/l_s)}{y_s/l_s}\right)\alpha_s\right)}_{\text{allocation component}} \tag{15}$$

A.2 Decomposing the allocation component

The allocation component is the covariance across sectors between sector-level growth in employment shares and sector-level size-weighted productivity growth. In principle, it can move, say increase, either because employment grows more quickly in higher productivity growth sectors or because productivity grows more quickly in sectors with rapidly expanding employment. To see this, let $\overline{x_s}^t$ be the average over time of any variable x_s and $\underline{x_s} = x_s - \overline{x_s}^t$ the deviation from the average. We can then write the allocation component as the sum of four terms:

$$cov\left(\frac{\Delta(l_s/l)}{l_s/l};\left(1+\frac{\Delta(y_s/l_s)}{y_s/l_s}\right)\alpha_s\right) = cov\left(\overline{\frac{\Delta(l_s/l)}{l_s/l}}^t;\overline{\left(1+\frac{\Delta(y_s/l_s)}{y_s/l_s}\right)\alpha_s}^t\right) + \tag{16}$$

$$cov\left(\overline{\frac{\Delta(l_s/l)}{l_s/l}}^t;\underline{\left(1+\frac{\Delta(y_s/l_s)}{y_s/l_s}\right)\alpha_s}\right) + cov\left(\underline{\frac{\Delta(l_s/l)}{l_s/l}};\overline{\left(1+\frac{\Delta(y_s/l_s)}{y_s/l_s}\right)\alpha_s}^t\right) + cov\left(\underline{\frac{\Delta(l_s/l)}{l_s/l}};\underline{\left(1+\frac{\Delta(y_s/l_s)}{y_s/l_s}\right)\alpha_s}\right)$$

The first term on the right-hand side measures the covariance across sectors between average growth in sectoral employment shares and average growth in sectoral size-weighted productivity growth. Since this varies only across countries, it will be captured by the country fixed effects in the regressions (16). The second term measures the covariance across sectors between average growth in sectoral employment shares and deviations of sectoral size-weighted productivity growth from averages. This component reflects the impact of changes in sector-level size-weighted productivity growth rates, holding changes in employment shares constant. We will call this second term the productivity-driven allocation component. The third term measures the covariance across sectors between deviations of growth in sectoral employment shares from averages and sectoral size-weighted productivity growth. This term captures the impact of changes in employment shares, holding size-weighted sectoral productivity growth constant. We will call this third term the employment-driven allocation component. Finally, the fourth term measures the covariance between deviations of sectoral growth in employment shares from their long-run averages and deviations of sectoral size-weighted productivity growth rates from their own long-run average. This term measures how the allocation component of productivity growth depends on both types of changes. We therefore call it the jointly driven allocation component.

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