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Output collapses and productivity destruction

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Abstract In this paper we analyze the long-run relationship between output collapses—defined as GDP falling substantially below trend—and total factor productivity (TFP). We use a panel of 76 developed and developing countries during the period 1960–2004 to identify episodes of output collapse and estimate counterfactual post-collapse TFP trends. Collapses are concentrated in developing countries, especially Africa and Latin America, and were particularly widespread in the 1980s in Latin America. Overall, output collapses are systematically associated with long-lasting declines in TFP. We explore the conditions under which collapses are least or most damaging, as well as the type of shocks that make collapses more likely or severe. Furthermore, we provide a quantification of the associated welfare loss with output collapses.

Keywords Growth · Recessions · Productivity · Recovery

JEL Classification F43 · O40

1 Introduction

This paper assesses the evolution of long-run total factor productivity (TFP) dynamics after a significant collapse of GDP and its associated welfare impact, measured by the resulting gap between actual and counterfactual levels of TFP. We focus on the TFP gap instead of the GDP gap in order to leave aside gross output reductions associated with lower factor accumulation. Thus, the TFP gap is a

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measure of efficiency costs directly linked to welfare losses, net of investment costs in factor accumulation. Cleary, the potential welfare costs of a GDP collapse will depend critically on the persistence of the subsequent TFP gap: i.e. the faster the recovery in productivity, the lower the welfare cost. Given our focus on welfare costs, we are particularly interested in exploring the conditions and shocks under which a GDP collapse is associated with a very persistent—possibly permanent—decline of aggregate productivity.

This focus on TFP jibes well with the well established finding that TFP is the main determinant of economic development in the long run (e.g. see Easterly and Levine 2001). For example, the empirical evidence of growth accounting exercises shows that a systematic shortfall in TFP growth is the main factor behind the widening gap in per capita income between Latin America and developed countries over the past 50 years (Blyde and Fernández-Arias 2005). This is also consistent with the evidence compiled by Kehoe and Prescott (2007) that changes in TFP are the main driver of the 16 great depressions during the 20th century studied in their book. While these papers basically perform an accounting exercise, in most cases the implicit causality goes from TFP shocks to output performance. A mechanic interpretation of our focus on the evolution of TFP after an output collapse could suggest an implicit causality in the opposite direction, but we acknowledge that causality could run both ways, as pointed out by Cerra and Saxena (2008).

While we explore the causal interpretation of growth collapses leading to persistent productivity effects by specifically looking at a subsample of collapse episodes generated by exogenous factors, by and large we take an agnostic approach.[1] Therefore, the main contribution of the paper is to explore the productivity dynamics after an output collapse and the transmission channels at work.

If collapses are associated with detrimental persistent effects on the level of TFP, then they may lead to a lower average growth rate of GDP over long periods of time. If so, output shocks may generate a widening income gap between those countries that experience lots of them and those that do not, on account of those countries with incomplete TFP recovery within the sampling period. In particular, a permanently lower level of TFP would translate into a permanent effect on the level of GDP and, therefore, a reduction in the long-term growth rates. If sharp output collapses are associated with persistent declines in TFP, they could be an important factor behind the absolute income divergence that has been observed in the world according to Pritchett (1997).

Our methodological approach is based on a characterization of the anatomy of events and an exploration of some factors that have a significant correlation with the magnitude and duration of the decline in TFP. This alternative to the standard cross-

[1] An alternative approach to avoid some of these endogeneity problems would be to focus on TFP collapses. However, in our sample all output collapses would also classify as TFP collapses for the same threshold. Furthermore, given that TFP is computed as Solow residuals, it tends to be more volatile and noisy, such that for a given threshold there tend to be more "false" episodes, which makes the focus on output collapses more appealing. Finally, the literature the paper relates to has been focusing on the dynamics of macroeconomic variables after output collapses, such that for comparability it is useful to concentrate on output collapses.

country panel approach used in the empirical growth literature has received some attention in recent times due to the methodological shortcomings of cross-country regressions and their disappointing results in terms of policy evaluation. For example, Pritchett (2000) points out that systematic differences across countries in volatility and trends of GDP series make cross-country growth regressions essentially uninformative, while an approach that establishes some stylized facts by analyzing episodes and events associated with surges or collapses of output might be more enlightening.[2]

From a theoretical point of view, once market equilibrium in factor accumulation and utilization is restored after an output collapse, the existence of permanent income effects depends on the resulting steady-state aggregate productivity or TFP. In fact, if steady-state productivity remains unchanged, then growth rates would be altered during the period of collapse and recovery but the (average) long-term growth rate over this cycle would not. Consequently, welfare costs would be limited, associated with the transitory cyclical downturn. By contrast, if the collapse is associated with a decline in steady-state TFP, that is to say, if there is "productivity destruction", then income would be reduced permanently and welfare costs would not be confined to a transition period but would continue accruing permanently.

In the framework of a neoclassical growth model, an output collapse may be caused by an exogenous collapse in TFP or by shocks to distortions on investment and utilization of physical capital and other inputs, called "wedges" in the literature (see Chari et al. 2007), with no permanent effect on productivity. By contrast, endogenous growth theory provides a better framework to understand the potential mechanisms by which output collapses, whatever their cause, could have a permanent impact on TFP. In these models, an output collapse may erode the fundamentals behind aggregate TFP, thus lowering trend GDP. Furthermore, in some endogenous growth models a collapse may actually diminish the steady-state rate of growth of TFP and consequently of GDP, further reducing trend GDP and increasing the welfare cost.[3]

A number of endogenous growth models could account for a permanent effect on TFP following an output shock. For example, in models of knowledge accumulation, like Romer (1990) and Grossman and Helpman (1991), a reduction in the fraction of the labor force engaged in research and development (R&D) could have permanent negative effects on the level of productivity. Moreover, if the production of new knowledge depends largely on the stock of existing knowledge, the growth rate of productivity could also be permanently affected. Therefore, in these models, shocks that affect the return of the factors engaged in R&D relative to those engaged in the production of final goods could have potential long standing consequences on productivity. Martin and Rogers (1997) employ an endogenous growth model in which labor productivity is augmented

[2] See e.g. on growth accelerations Hausmann et al. (2005), as well as Jones and Olken (2008) on accelerations and decelerations.

[3] In addition, the steady-state TFP level usually is a determinant of the steady-state growth rate in these models, such that a permanent level effect could potentially also have a deteriorating effect on the steady-state growth rate of output.

through learning by doing to show that recessions are periods in which opportunities for acquiring experience and improving productivity are foregone. Even if productivity growth resumes after a recession, there would be a permanent wedge in the level of productivity.

There is a growing literature studying the role of policy distortions and TFP (see e.g. Parente and Prescott 2000). Restuccia and Rogerson (2008), for example, develop a model of firm heterogeneity in which policies that distort the relative price faced by individual firms can result in large declines of aggregate productivity due to the misallocation of resources. Although not directly related to recessions, the model implies that if crises lead to an upsurge of these distortionary policies, aggregate TFP and output could be significantly affected in the long-run. The facts show that governments often use subsidies, tariffs and quotas, undervalued exchange rates or other policies after recessions to revitalize output and employment. Although such policies can ignite the economy in the short run, they may also hinder aggregate efficiency in the long run to the extent they are not removed and lead to misallocation of resources. Furthermore, output collapses might be accompanied by institutional and social breakdowns, which may destroy intangible "capital" needed for efficient economic cooperation.

There is another strand of the literature that shows that economic crisis may have positive impacts on TFP. Following Schumpeter's notion of creative destruction, Caballero and Hammour (1994), for example, show that recessions may cleanse the economy of inefficient firms, leading to higher productivity and output growth. A related idea is the "pit-stop" view of recessions, according to which recessions are seen as times when profitability is low and, therefore, much needed restructuring can be undertaken because of a temporarily low opportunity cost (Aghion and Saint-Paul 1998).[4] Ranciere et al. (2008) present evidence that countries which have suffered occasional crises—identified as a sharp collapse in credit growth—grow faster. They also present a model consistent with a positive correlation between risk and economic growth under certain conditions. In addition, there is also a political economy argument for a positive effect of crises on growth. For example Tommasi and Velsco (1996)argue that economic crises facilitate economic reforms.[5]

As the discussion above shows, in theory it is possible that output collapses are associated with positive or negative effects on productivity that last for long periods of time or even permanently. As an empirical matter, there are a number of papers in the literature that address related issues. Cerra and Saxena (2008) use panel-VAR techniques to show that GDP growth is significantly and persistently lower after financial crises and some types of political crises. Our work is complementary to their, given that they do not explore whether this persistent decline in growth is due to a decline in factor accumulation or mainly due to a lower TFP growth.

[4] Empirically, however, there is evidence that this restructuring process does not always occur. For example, using data on US manufacturing firms, Caballero and Hammour (2005) show that the restructuring process is *depressed*, not increased, by an aggregate recessionary shock.

[5] In a related paper, Drazen and Easterly (2001) test the hypothesis that macroeconomic crises induce growth acceleration but fail to find significant effects.

Jones and Olken (2008) identify episodes of GDP growth accelerations and collapses using a small-sample version of a structural break tests by Bai and Perron (1998, 2003) to detect regime changes. They identify 73 breaks in 48 countries using Penn World Table data, of which 43 are down-breaks and 30 up-breaks. Their results show interesting asymmetries between growth ignitions and collapses. In particular, while growth accelerations are associated with increases in trade, without a significant change in investment rates, collapses in GDP growth are associated with a significantly lower investment, inflation, devaluations and internal conflict.

Our approach differs in various aspects from this paper. We concentrate on the question of whether TFP returns to it potential level taking into account initial conditions and the evolution of the TFP frontier. More than 62% of all the collapses identified by Jones and Olken (2008) occurred in the 1970's during the global productivity slowdown of the world economy. This suggests that—especially for developing countries—it is important to take into account what happens to its technological frontier in order to construct the level of TFP that would have prevailed in the absence of a crisis. Second, we focus on output collapses, defined as a large departure below the trend level of GDP, rather than growth collapses, which can be the natural consequence of an unsustainable boom, without implying a major crisis with destructive potential. Furthermore, we identify the events as a decline below a common threshold for all countries. This has the advantage that we capture all large events, rather than relying on a statistical identification of events that depends critically on the variability of the time series. This limitation explains why important crises, like the Uruguayan currency and banking crises in the early 1980's, Argentina's collapse during the hyperinflation of 1989, or Chile's collapse around the rise and fall of the Allende regime, are not identified as episodes using Jones and Olken's methodology.

Several additional papers look at growth performance during extreme events, although without reference to productivity or other structural underpinnings relevant for long-run effects on income and welfare which are the focus of our paper. For example, similar to Jones and Olken (2008), Berg et al. (2006) and Hausmann et al. (2006) analyze the factors related to the duration of growth spells or collapses. Becker and Mauro (2006) analyze episodes of output drops but their main concern is on the nature of the shocks behind these drops rather than on the evolution of productivity. We use several of their classifications of shocks to analyze whether the evolution of TFP differs according to the type of shocks associated with the output collapse. Hong and Tornell (2005) analyze the recovery of GDP growth during currency crises. They find that growth rates rapidly return to pre-crisis levels but may not surpass them, thus possibly producing a persistent effect on GDP levels, but in contrast to our paper, they focus on cyclical GDP dynamics during currency crisis. Finally, our paper is also somewhat related to Calvo et al. (2006) on the miraculous recoveries after systemic financial crises. However, their emphasis is on the short-run or cyclical performance of TFP during systemic sudden stops in capital flows to emerging markets, while we focus on the long-run or permanent consequences of a broader class of output collapses.

We look at a panel of 76 countries during the period 1960–2004 to identify episodes of GDP collapses and estimate the counterfactual post-collapse TFP trend.

We test whether output collapses are systematically associated with temporary or permanent declines of aggregate productivity and measure their welfare costs in terms of GDP forgone. Although results differ across countries and regions, the analysis shows that the losses from productivity destruction can be substantial. In addition, we characterize the types of shocks that are associated with output collapses and quantify the corresponding welfare losses.[6]

The paper is organized as follows. Section 2 describes the data and identifies the output collapses in the sample. The next section constructs the counterfactuals of trend TFP and tests whether the effects on productivity after collapses are temporary or permanent. It also analyzes how these effects differ across time and regions, and performs some robustness checks. In Sect. 4 we explore how productivity effects differ depending on the types of shocks associated with output collapses and estimate the extent of the post-collapse loss in terms of the welfare costs. Section 5 concludes.

2 Identification of output collapses

The main focus of the paper is the behavior of TFP in the long run. Therefore, our sample comprises countries for which we could construct long series of GDP, physical capital, labor inputs and education. The sample consists of 76 countries (shown in Table 8 in the "Appendix"), which is the maximum number of countries with available information, for the period 1960–2004. The TFP series are computed for each country as a residual from the following Cobb–Douglas production function.[7] The real GDP (PPP-adjusted) and investment data are taken from the Penn World Table 6.2. Capital stocks are constructed using perpetual inventory method—as it standard in the literature—following the parameterization of Easterly and Levine (2001). The labor input is measured by the labor force, also from PWT 6.2. We follow Hall and Jones (1999) and construct series for the relative efficiency of a unit of labor based on years of education. The data on education is taken from the Barro and Lee (2000) data set. For more details on the series and TFP computation see Blyde et al. (2008) and Daude and Fernández-Arias (2010).

2.1 Collapses in output

There is no unique way to identify collapses in output. We consider that an economy has experienced a collapse when its output falls significantly below its potential or trend level.[8] An alternative approach would be to look at a collapse in the growth rate. However, a large negative growth rate of output is not necessarily an indication

[6] In Blyde et al. (2008) for the sake of completeness we also analyze the behavior of factor accumulation after a collapse. We show that most of the reduction in GDP per capita is due to lower TFP rather than physical investment.

[7] Such that $Y = AK^{\alpha}(hL)^{1-\alpha}$, where Y represent domestic output, K physical capital, L labor force, h the average quality of the labor force and A is measured TFP.

[8] A similar definition is used in Bergoeing et al. (2004).

of a crisis as the economy might be returning to its equilibrium after a period of unusually high growth. Our definition of collapse (a substantial negative gap between the observed output level and its potential or trend level) excludes these episodes. For example, if we define a growth collapse as a decline in real GDP growth by more than two standard deviations from the country's average growth rate, out of 80 episodes of this type in our sample only 27 are also output collapses in our definition.

In order to calculate the relevant output gap, we first de-trend GDP per capita on a country-by-country basis using the Hodrick–Prescott filter. Then we identify and select only output gaps that are 6% or larger, which is also the average decline in GDP growth rates for the collapses identified by Jones and Olken (2008) using time-series structural break tests by country. Alternatively, we also use the largest 5% deviations from trend across country in the whole sample. As pointed out above, the advantage of a uniform threshold across countries is that this procedure makes sure that our events are "large" from an economic point of view. In contrast, if we were to consider extreme events from a statistical point of view on a country-by-country basis, e.g. events that fall below two or three standard deviations, economically small collapses in countries with very low volatility would be identified as events, while large crises might go undetected in countries with high output volatility.

Given that prolonged depressions and periods of instability often imply consecutive output gaps below the threshold, we proceeded to eliminate all episodes that follow in a three-year span another episode. Furthermore, because some of the collapses occurred very early in the sample period, the lack of adequate numbers of observations does not allow an accurate estimation of the counterfactual.[9] In some other cases, like Argentina 2002, the collapse occurred only 2 years before the end of the sample period. For these particular cases, making a comparison after such a short period of time would bias the results towards a "lack of recovery" type of story. Therefore, we also eliminate episodes that took place within less than 4 years from the end of our sample. After these adjustments, we are left with 75 collapses considering the 6% threshold, and 65 episodes for the alternative threshold.

Table 1 shows the collapses by countries and years for both definitions of collapses used in the paper. Only two are in developed countries (Finland 1992, and Portugal 1986), although there are also four collapses in high-income non-OECD countries, Hong Kong and Singapore. All the other collapses are found in developing countries. Figure 1 shows the number of collapses by decades and regions. Sub-Saharan Africa (SSA) and Latin America are the regions with most collapses (28 and 22, respectively), followed by the Asian countries (ASIA), Middle East and Northern Africa (MENA) and OTHER (which basically includes Finland and Portugal and developing countries in Europe). The 1980s is the decade with most collapses (34 episodes). The number of collapses during this decade almost

[9] Also, measured TFP in early sample periods might be affected by the assumptions regarding the construction of the capital stock. Daude and Fernández-Arias (2010) show that after a ten-year period alternative measures of capital tend to converge.

Table 1 Output collapse episodes 1970–1999

Country	Year	Deviation from trend output	Top 5%	Country	Year	Deviation from trend output	Top 5%
Algeria	1971	−0.07	Yes	Mali	1973	−0.06	No
Argentina	1989	−0.11	Yes	Mali	1982	−0.07	Yes
Benin	1977	−0.10	Yes	Mexico	1995	−0.06	No
Bolivia	1970	−0.07	Yes	Mozambique	1985	−0.17	Yes
Brazil	1983	−0.09	Yes	Nepal	1980	−0.06	No
Cameroon	1977	−0.07	Yes	Nicaragua	1979	−0.10	Yes
Cameroon	1993	−0.06	No	Nicaragua	1991	−0.07	Yes
Chile	1975	−0.14	Yes	Niger	1973	−0.17	Yes
Chile	1983	−0.08	Yes	Niger	1984	−0.08	Yes
Costa Rica	1982	−0.07	Yes	Niger	1996	−0.06	No
Dominican Republic	1990	−0.07	Yes	Panama	1979	−0.06	No
Ecuador	1987	−0.09	Yes	Panama	1988	−0.08	Yes
Egypt	1975	−0.11	Yes	Papua New Guinea	1974	−0.10	Yes
Fiji	1983	−0.07	Yes	Papua New Guinea	1990	−0.13	Yes
Finland	1992	−0.07	Yes	Peru	1983	−0.08	Yes
Ghana	1976	−0.08	Yes	Peru	1989	−0.07	Yes
Ghana	1983	−0.07	Yes	Philippines	1985	−0.08	Yes
Ghana	1997	−0.09	Yes	Portugal	1984	−0.08	Yes
Honduras	1974	−0.09	Yes	Senegal	1973	−0.06	No
Hong Kong	1975	−0.09	Yes	Senegal	1981	−0.07	Yes
Hong Kong	1985	−0.07	Yes	Sierra Leone	1992	−0.09	Yes
Hong Kong	1999	−0.07	Yes	Sierra Leone	1998	−0.07	Yes
Hungary	1991	−0.07	Yes	Singapore	1986	−0.09	Yes
Indonesia	1982	−0.09	Yes	Syria	1977	−0.09	Yes
Iran	1981	−0.20	Yes	Syria	1987	−0.07	Yes
Iran	1987	−0.07	Yes	Thailand	1986	−0.06	No
Jamaica	1980	−0.07	Yes	Thailand	1998	−0.07	Yes
Jamaica	1985	−0.07	Yes	Togo	1983	−0.08	Yes
Jordan	1974	−0.08	Yes	Togo	1993	−0.07	Yes
Jordan	1990	−0.14	Yes	Turkey	1980	−0.06	No
Kenya	1970	−0.07	Yes	Uganda	1979	−0.07	Yes
Kenya	1985	−0.08	Yes	Uganda	1988	−0.06	No
Korea	1998	−0.09	Yes	Uruguay	1983	−0.08	Yes
Lesotho	1971	−0.08	Yes	Uruguay	1990	−0.06	No
Lesotho	1991	−0.07	Yes	Venezuela	1971	−0.08	Yes
Malawi	1970	−0.12	Yes	Venezuela	1983	−0.07	Yes
Malawi	1992	−0.18	Yes	Zambia	1986	−0.08	Yes
Malaysia	1987	−0.07	Yes	Zambia	1995	−0.11	Yes

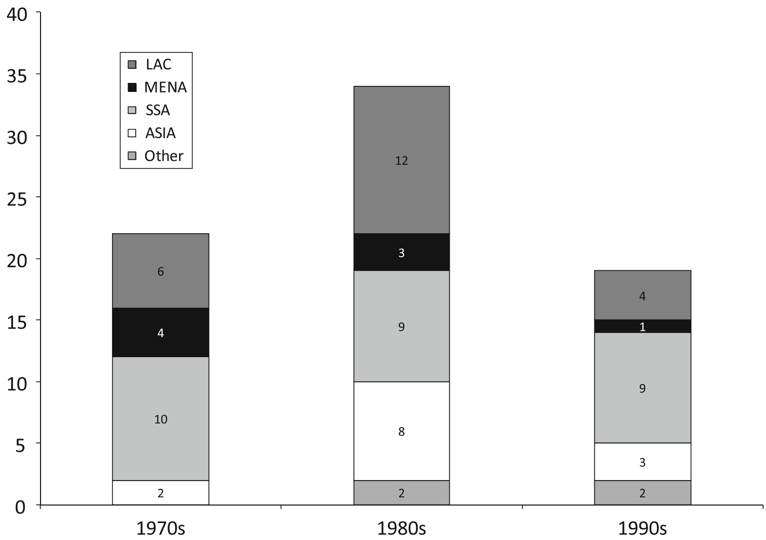

Fig. 1 Number of episodes by decade and region

doubles the number of collapses in the 1990s and is also significantly larger than the 1970s. Latin America has been particularly prone to collapses in the 1980s, with more than half of the collapses concentrating in this period, known as "the lost decade"; however, also in Asia more than 60% of the episodes in the region are concentrated in this period.

Now that we have identified the output collapses in the sample we are in the position to analyze how TFP behaves afterwards. This is done in the next section.

3 TFP after output collapses

The main objective of this section is to find out whether output collapses are associated with persistent, possibly permanent effects on aggregate productivity. Therefore, we construct counterfactuals of post-collapse TFP to compare with "actual", i.e. measured, TFP. As we are interested in making predictions of what would have been the TFP of a country had the collapse not occurred, the models are estimated using only country data prior to the collapse as well as the full sample data for countries in our sample without a collapse (which act as a control group).

The simplest counterfactual model would be linear growth forecasts of the TFP level over time t for each country i (which we refer as the "linear model"):

$$\ln(\mathrm{TFP}_{it}) = \alpha_i + \beta_i t + \varepsilon_{it} \tag{1}$$

Alternatively, we also consider a model that only includes the evolution of the productivity frontier allowing for "country specific absorption", in the spirit of Parente and Prescott (2005):

$$\ln(\mathrm{TFP}_{it}) = \alpha_i + \lambda_i \ln(\mathrm{TFP}^f_t) + \varepsilon_{it} \tag{2}$$

A counterfactual forecast based a model (1) would fail to detect systemic changes over time to the rate of growth of world productivity that may influence each country's potential TFP. A slowdown or an acceleration of the productivity frontier that may have occurred after the collapse could influence the post-collapse evolution of TFP. In order to account for this effect, we augmented the linear model with a term that captures the evolution of the productivity frontier:

$$\ln(\mathrm{TFP}_{it}) = \alpha_i + \beta_i t + \lambda \ln(\mathrm{TFP}^f_t) + \varepsilon_{it} \tag{3}$$

where TFP^f_t refers to the TFP of the productivity frontier and is proxied by the simple average of TFP for the 20 developed countries in the sample. We refer to this model as the "country-specific trend with absorption" counterfactual.

For completeness, we also consider a "country-specific absorption with trend" model:[10]

$$\ln(\mathrm{TFP}_{it}) = \alpha_i + \beta t + \lambda_i \ln(\mathrm{TFP}^f_t) + \varepsilon_{it} \tag{4}$$

Countries with more than one episode of output collapse should also have one counterfactual path for TFP for each collapse. Therefore, for the purpose of estimating the counterfactual models presented above, the index i refers to each episode, possibly in the same country. All the episodes are estimated using data from the beginning of the sample until the year prior to the collapse, which is consistent with the null hypothesis that collapses do not have persistent effects on TFP.

Given that we are interested primarily in long-run effects, we would like to compare the actual level of the TFP of a country that has collapsed with its counterfactual at the farthest possible moment of time after the collapse has occurred; this is, at the end of our sample period or just before another collapse occurred. Hence, for each episode we construct the log-difference of actual TFP versus its counterfactual and then test if on average this difference is significantly different from 0. The results are shown in Table 2. It is important to point out that the level of TFP in any specific year could be unusually high or unusually low because our measure of TFP is affected by the business cycle, which introduces noise to the tests. Therefore, we compare the counterfactual in a particular year not with measured TFP in that year but with its trend.[11]

The first column in Table 2 shows the case when counterfactuals are estimated with the linear model specified in Eq. (1) above. On average, measured TFP ratio is around 22% points below its counterfactual at the end of the sample. In addition, the t-statistic shows that the null hypothesis of no significant difference is rejected at standard levels of confidence. For the other three alternative counterfactuals, the

[10] It is important to point out that some sort of stationarity of TFP. Standard unit root tests (Maddala and Wu 1999; Im et al. 2003; Pesaran 2003; and Levin et al. 2002), confirm this assumption for the countries in the sample that did not experience a collapse. However, for the subsample of countries that experienced a collapse, the unit root assumption cannot be rejected. An alternative estimation of the impact of an output collapse in the absences of stationarity is presented later in this section.

[11] The trend is calculated with the Hodrick–Prescott filter applied to the entire TFP series, using a smoothing parameter of 6.25 suggested by Uhlig and Ravn (2002).

Table 2 Measured TFP versus counterfactual TFP for baseline collapses

Series/sample	Observations	Linear trend	Country-specific absorption	Country-specific trend with absorption	Country-specific absorption with trend
HP-filtered TFP series	75	−0.222	−0.172	−0.074	−0.123
p-value		0.00	0.00	0.04	0.00
Original TFP series	75	−0.224	−0.174	−0.076	−0.125
p-value		0.00	0.00	0.03	0.00
Latin America and the Caribbean	22	−0.275	−0.241	−0.136	−0.192
p-value		0.00	0.00	0.03	0.00
Sub-Saharan Africa	28	−0.151	−0.136	−0.006	−0.090
p-value		0.02	0.00	0.92	0.06
Middle East and Northern Africa	8	−0.374	−0.341	−0.135	−0.277
p-value		0.11	0.04	0.51	0.09
Asia	13	−0.185	−0.041	−0.060	0.008
p-value		0.00	0.35	0.19	0.86
Rest	4	−0.243	−0.138	−0.135	−0.088
p-value		0.08	0.16	0.19	0.28
1970's	22	−0.340	−0.178	−0.041	−0.115
p-value		0.00	0.01	0.60	0.06
1980's	34	−0.200	−0.180	−0.078	−0.126
p-value		0.00	0.00	0.16	0.01
1990's	19	−0.125	−0.153	−0.104	−0.127
p-value		0.01	0.00	0.03	0.01

The table presents *t*-statistics of the null hypothesis that the log-difference between measured TFP and counterfactual TFP is equal to zero. Baseline collapses refer to episodes with an output gaps greater than 6%

resulting TFP difference is smaller (between 7.4 and 17.2%), but statistically significant at a confidence level of 95%. Thus, typically TFP does not return to pre-collapse levels. In all four cases, TFP ends up significantly below the level of TFP that would have prevailed if the collapse had not occurred. Therefore, when we consider all the models, results indicate that output collapses have been followed by very persistent negative effects on productivity. This evidence is consistent with the findings of Aguiar and Gopinath (2007) regarding a higher incidence of structural breaks in TFP trends in developing countries compared to industrialized countries.

It is worth noting that the end-of-sample period is, on average, 13.6 years after the collapses have occurred. Therefore, it is difficult to argue that the failure of TFP to return to its potential level is due to the lack of time to recover within the sample. In order to explore this issue further, in Fig. 2 we plot the log-difference between measured TFP and the counterfactual (based on Eq. 4) at the end of sample against

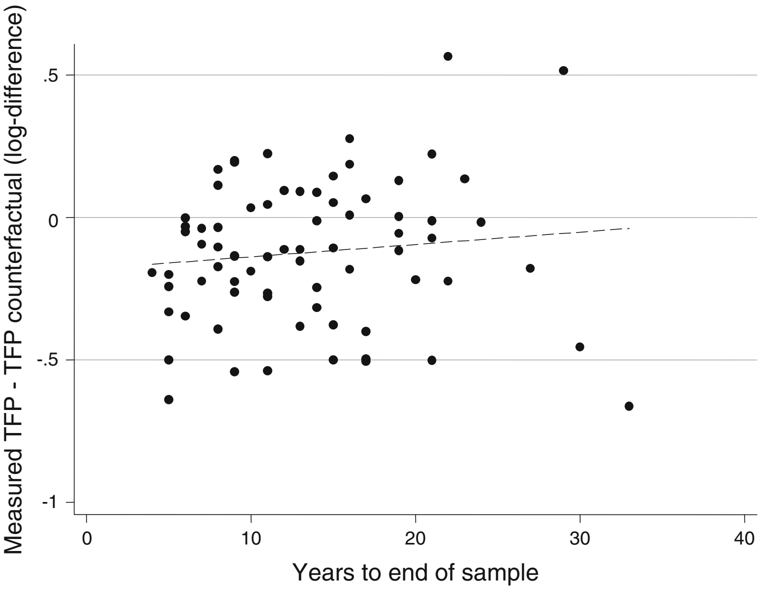

Fig. 2 Correlation between distance to end of sample and severity of the collapse

the years left to reach the end of sample for each episode. As seen clearly in the scatter plot, there is a slightly positive correlation of 0.11, but it is not significant at conventional levels (its *p*-value is 0.36). Thus, a systematic bias due to sample truncation does not seem to be driving our results regarding lack of recovery in TFP. Furthermore, even if we were to consider the point estimates as significant—they imply that on average—it would take around 45 years to close the gap between measure and counterfactual TFP.

The following line in Table 2 measures the difference of the original TFP series rather than the filtered series with respect to the four alternative counterfactuals. As it can been, the tests show similar economic and statistical levels of significance. Therefore, in the rest of the paper we will consider the filtered TFP series.

The remaining lines of Table 2 analyze the performance of TFP in the aftermath of an output collapse across regions as well as across decades. In the case of Latin America, all models to construct TFP counterfactuals clearly support the argument that TFP failed to return to its potential trend after an output collapse. Furthermore, TFP contractions seem to be more severe in LAC, implying on average an incremental decline between 5.3 and 6.9% points (depending on the counterfactual). For the case of Sub-Saharan Africa, the results also indicate a significant decline in TFP in three of the four counterfactuals. Although the magnitudes are slightly smaller, they still imply an economically significant decline of between 9 and 15% in TFP. For the MENA region, the point estimates of TFP reductions are quite large, and significantly at conventional levels in two of the cases. However, while the small sample might reduce the statistically significance, TFP declines seem to be pretty large in the region. In the case of Asia, the evidence shows no permanent and significant reduction in TFP. Only for the linear-trend counterfactual there is a significant decline. A similar result is found for the countries aggregates in the residual region. Thus, we find strong evidence that collapses have generated long-run detrimental effects on productivity in Latin America, Sub-Saharan Africa and to some extent also for the MENA region, while the evidence is weak for Asia.[12]

Across decades, the results in Table 2 show that collapses in all periods had a significantly detrimental effect on TFP, although in the 1990's they seem to have been less severe.

In Table 3, we present the same tests as in Table 2, but restricting ourselves to the 5% largest collapses in the sample. The results are quite similar to those presented in Table 2. LAC and MENA are the regions with the most intense and significant contractions, while in Asia output collapses do not seem to have long-lasting effects on TFP.

3.1 Robustness checks

Table 4 presents some basic robustness checks of our results so far. First, we analyze whether our results are sensitive to the way our capital stock is measured. This issue is potentially of importance, given that TFP is measured as a residual, and therefore it would capture potential measurement errors in the remaining variables. The alternative measure is based on Caselli (2005) who considers different steady-state conditions (based on the growth rate of investment rather than GDP and investment-to-GDP ratios as we do in this paper).[13] As shown in the first line of Table 3, with this alternative measure of TFP, the decline in TFP following an output collapse is somewhat smaller in magnitude—between an 8 and 16%—but economically and statistically significant for all four counterfactuals.

Next, we consider whether large declines in the output gap are different from small collapses, by considering the largest quartile of collapses in our sample versus the rest.[14] As lines 2 and 3 of the table show, both types of episodes imply a significant decline in TFP. Therefore, our results are not driven by a small number of extreme events. Furthermore, large collapses are associated with significantly larger declines in TFP.[15] Large collapses are associated with declines in TFP that are between 64 and 205% more severe than small collapses.

Finally, we investigate whether there are differences between episodes if they were preceded by a boom in the previous 3 years, defined symmetrically as a positive output per capita gap of at least 6%, or not. Collapse could be a consequence of unsustainable booms. This could have important welfare implications, because if only episodes that were preceded by a boom suffer a reduction in

[12] Our results from the linear model, although not strictly comparable, are in line with those in Cerra and Saxena (2008). They find that after a recession, output does not recoup the level associated with the *linear* extrapolation of the original trend.

[13] See Caselli (2005) for more details.

[14] These are collapses with output gap below -8.9% in our sample.

[15] In all four cases, a test of equal means between samples is rejected at conventional levels of significance.

Table 3 Measured TFP versus counterfactual TFP for Top 5% Collapses

Series/sample	Observations	Linear trend	Country-specific absorption	Country-specific trend with absorption	Country-specific absorption with trend
HP-filtered TFP series	65	−0.251	−0.188	−0.076	−0.126
p-value		0.00	0.00	0.06	0.00
Original TFP series	65	−0.251	−0.187	−0.075	−0.125
p-value		0.00	0.00	0.07	0.00
Latin America and the Caribbean	20	−0.318	−0.282	−0.170	−0.224
p-value		0.00	0.00	0.01	0.00
Sub-Saharan Africa	23	−0.190	−0.152	−0.008	−0.091
p-value		0.00	0.00	0.89	0.08
Middle East and Northern Africa	8	−0.367	−0.335	−0.118	−0.262
p-value		0.13	0.05	0.57	0.10
Asia	12	−0.196	−0.013	−0.021	0.049
p-value		0.01	0.81	0.80	0.43
Rest	2	−0.147	−0.100	−0.069	−0.049
p-value		0.62	0.68	0.74	0.81
1970's	19	−0.395	−0.165	−0.010	−0.078
p-value		0.00	0.03	0.92	0.27
1980's	30	−0.215	−0.207	−0.090	−0.144
p-value		0.00	0.00	0.13	0.01
1990's	16	−0.147	−0.177	−0.128	−0.148
p-value		0.01	0.00	0.02	0.01

The table presents *t*-statistics of the null hypothesis that the log-difference between measured TFP and counterfactual TFP is equal to zero

TFP, then the pre-collapse gains should be discounted from the after-collapse welfare costs. Furthermore, costs could be associated with a more volatile output (second moments), rather than reduction in the mean. As our results show, although there is some evidence of TFP reduction being more severe if the output collapse was preceded by a boom, episodes are not associated with a previous boom also bring significant losses in terms of TFP levels. Thus, mean-reversion arguments represent only a fraction of the TFP reduction that follows an output collapse.

Next, we perform additional robustness checks by estimating the effect of output collapses directly using econometric panel techniques, which allows us also to use the countries that did not have a collapse as a control group. In particular, we estimate a variation of Eqs. (1)–(4) including a dummy $Post\text{-}collapse_{it}$ which takes the value of 1 from period t onwards if in year t there has been a collapse in country i. As shown in Table 5, panel fixed-effects estimations for the four models all yield a significant reduction of TFP after an output collapse of between 8 and 10%. It should be pointed out that the difference in magnitude between these estimates and those presented in Tables 2–4 is probably driven by the fact that in the regressions

Table 4 Robustness checks

	Observations	Linear trend	Country-specific absorption	Country-specific trend with absorption	Country-specific absorption with trend
Caselli TFP measure	75	−0.151	−0.161	−0.080	−0.098
p-value		0.01	0.00	0.06	0.01
Large collapses (1st quartile)	20	−0.336	−0.226	−0.146	−0.172
p-value		0.00	0.00	0.07	0.01
Small collapses (rest)	55	−0.181	−0.153	−0.048	−0.105
p-value		0.00	0.00	0.23	0.00
Preceeded by a boom	26	−0.269	−0.197	−0.104	−0.145
p-value		0.00	0.00	0.07	0.01
No previous boom	49	−0.197	−0.159	−0.058	−0.111
p-value		0.00	0.00	0.21	0.00

The table presents *t*-statistics of the null hypothesis that the log-difference between Hp-filtered measured TFP and counterfactual TFP is equal to zero

we are capturing the average TFP loss, while in our previous analysis we are focusing on the loss at the end of sample. In column 5 of Table 5, we estimate the counterfactual from Eq. (4) correcting for potential autocorrelation and correlated panel-errors. The estimates show the presence of autocorrelation in the error term. However, the estimated impact remains very similar to the previous estimates, with a significant average decline in TFP of around 9.3%. Alternatively, in the next column we estimate the model in first-differences, which does not rely on the stationarity assumption of TFP; again the estimated effect is quite similar: 8.7%. Finally, in the last column we estimate a dynamic panel model addressing the potential endogeneity of the collapse. As the results show, there continues to be a significant decline in TFP in the aftermath of a collapse. While the coefficient is smaller than in the previous estimates, it should be pointed out that to be comparable, one has to compute the implied long-run elasticity taking into account the effect of the lagged dependent variable. When doing so, the estimated long-run decline in TFP following a collapse is around 12.5%.[16]

In order to analyze closer the dynamics of TFP in the aftermath of an output collapse, we follow Cerra and Saxena (2008) and estimate the following VAR-style panel:

$$\ln(\mathrm{TFP}_{it}) = \alpha + \sum_{j=1}^{4} \beta_j \ln(\mathrm{TFP}_{it-j}) + \sum_{j=0}^{4} \delta_j D_{it-j} + \varepsilon_{it}, \tag{5}$$

[16] This results from −0.031/(1−0.752) = −0.125.

Table 5 Panel estimation of the impact of an output collapse on TFP

	Fixed effects	Fixed effects	Fixed effects	Fixed effects	Prais–Winsten[a]	First-diff.	Arellano–Bond[b]
Lagged log(TFP)	–	–	–	–	–	–	0.752 (0.026)***
Post-collapse	−0.083 (0.022)***	−0.103 (0.024)***	−0.080 (0.022)***	−0.087 (0.023)***	−0.093 (0.008)***	−0.087 (0.006)***	−0.031 (0.011)***
Observations	3210	3210	3210	3210	3210	3210	3210
R-sq within	0.711	0.669	0.719	0.677	–	–	–
R-sq overall	0.015	0.014	0.015	0.013	0.980	0.107	–
AR1-error term	–	–	–	–	0.882	–	–
AR(2) test (*p*-value)	–	–	–	–	–	–	0.795
Additional controls							
Fixed effects	Country effects	Country effects	Country effects	Country effects	Country effects		Country effects
Trends	Country-specific	–	Common	Country-specific	Country-specific	Country-specific	Country-specific
TFP frontier	–	Country-specific	Country-specific	Common	Common	Common	Common

*** Significant at 1%

[a] Panel-corrected correlated standard error estimation

[b] Robust variance–covariance errors estimation

where D_{it} is the collapse dummy which takes value one if there is an output collapse episode in country i at time t.

In Fig. 3, we show the cumulative impulse-response function from assuming a collapse at time t, based on three of the alternative econometric models considered in Table 5. Under the three specifications, on impact there is a similar decline in TFP of around 8%, and a deepening of the effect in the following 2 years. While in the first-difference model the effects amplifies to a cumulative decline in TFP of around 20% after 5 years, the decline stabilizes at 12% using the corrected panel-error model (Prais–Winsten estimator), and there is some recovery under the fixed effects model, but still a significant TFP loss of around 8.5%.[17]

The potential issue of endogeneity is not easy to deal with, given the lack of obvious and valid instruments. In Fig. 4, we explore the temporal profile of the impact of an output collapse on TFP including two-year leads and lags of a collapse dummy (taking value one if at time t there is an output collapse in country i).[18] Significant impacts previous to the date of the collapse would be a clear indication of reverse causality. As Fig. 4 shows, this is not the case. There is no significant

[17] Given that the fixed effects estimator is clearly biased and inconsistent this latter result should be interpreted with care.

[18] The presented estimates are based on the Prais–Winsten estimation under the counterfactual specification from Eq. (4).

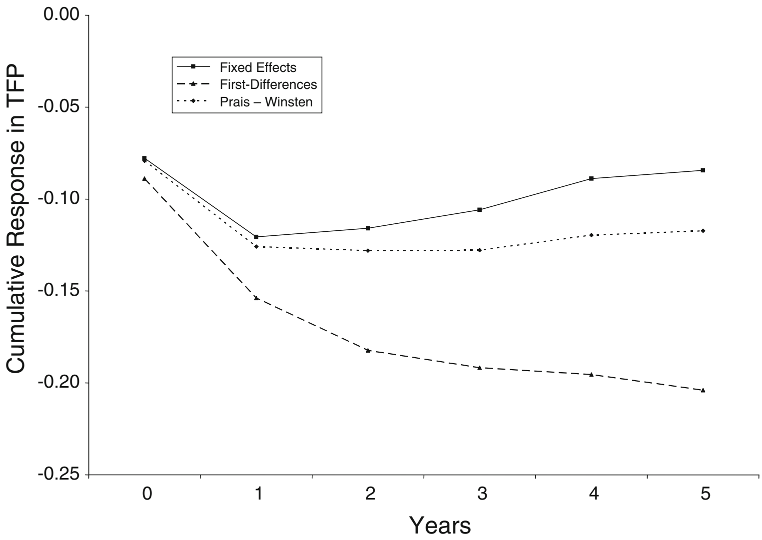

Fig. 3 Cumulative impulse-response to an output collapse

anticipated effect on TFP. The major effect takes place at moment *t*, with also additional significant effects in two following years. Clearly, although this analysis yields some interesting results and makes reverse causality less likely to be driving our results, it is not possible to discard the simultaneity of TFP and collapses based on this analysis. In order to explore this issue further, in the next section we study how TFP evolves during collapses that are associated with rather exogenous shocks.

4 Exploring the impact of different types of shocks

In this section, we explore a series of shocks that have been identified by the literature as sources for serious macroeconomic disturbances. The definitions and sources are similar to the shocks used by Becker and Mauro (2006).

The first group of shocks we analyze involves more exogenous economic shocks, which allows us to explore further the importance of endogeneity of collapses driving our results. First, we consider episodes of negative terms of trade (TOT) shocks, represented by a dummy variable that takes the value of 1 when a country's TOT growth rate falls below two standard deviations.[19] In addition, we also consider global external shocks such as oil shocks and increases in international interest rates. Oil shock episodes are identified as years in which the price increase of crude oil is greater than one standard deviation. The resulting years when oil shocks took place are 1974, 1979, 1999 and 2002. International interest rate shocks are identified as years in which the effective Federal Funds rate increased by more than 150 basis points. Finally, the natural disaster dummy is constructed based on

[19] Terms of trade data are from the IMF's internal WEO database.

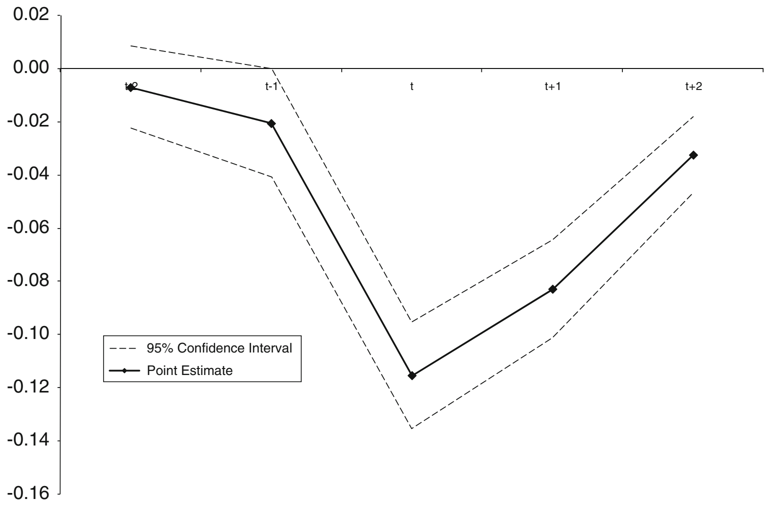

Fig. 4 Estimated impact over time on TFP of an output collapse at time *t*

the data from Em-Dat (2009) [20] and takes the value of 1 if more than a 0.01% of the country's population was killed in the incident.

The second group of shocks involves macroeconomic shocks that might be triggered by external events, but potentially also some domestic determinants, such as currency crises, banking crises and sovereign debt crises. We define a currency crisis in two ways. A real currency crisis is defined following Fernández-Arias et al. (2002) as a situation in which the real exchange rate depreciated by more than 10% in any month, and is represented by a dummy variable taking the value of one in the year of the crisis. A nominal currency crisis is defined as an episode with 10% depreciation in any month.[21] For banking and debt crises, we rely on episodes reported by Laevan and Valencia (2008).[22]

Finally, a third group of variables includes political shocks such as internal wars and major regime changes (e.g. coups d'état). The war dummy takes the value of 1 if the country is involved in an internal civil war according to information from the Correlates of War database, while the political shock dummy is constructed as an event with a major regime change (deterioration) base on the Polity IV database.[23]

[20] They are available at www.em-dat.net.

[21] Clearly, the latter situation also includes high inflation environments with a high nominal depreciation. We also tried different thresholds, e.g. considering 5% depreciation, and results did not change significantly.

[22] This comprehensive database covers events in 163 countries between 1970 and 2007. The database includes most episodes in the literature for banking crisis, like Bell and Pain (2000), Caprio and Klingebiel (2003), Demirgüç-Kunt and Detragiache (2005), and Kaminsky and Reinhart (1999), as well as debt crisis reported by Detraigiache and Spilimbergo (2001), Manasse and Roubini (2005), and Reinhart et al. (2003).

[23] We define this shock as a deterioration of 3 or more points in the country's polity index.

Table 6 Shocks and output collapse episodes

Type of shock	Number of events	Number of collapses	Frequency of shock	Frequency of collapse given shock	Noise-to-signal
Terms of trade shock	83	32	0.038	0.386	0.057
Interest rate shock	584	34	0.267	0.058	0.574
Oil price shock	219	18	0.100	0.082	0.396
Natural disaster	32	3	0.015	0.094	0.343
Real currency shock	376	40	0.172	0.106	0.298
Nominal currency shock	104	29	0.047	0.279	0.092
Banking crisis	67	20	0.031	0.299	0.083
Debt crisis	36	15	0.016	0.417	0.050
Political shock	39	9	0.018	0.231	0.118
Internal war	140	13	0.064	0.093	0.346

The degree of association of the different types of shocks with output collapses is shown in Table 6. With the above definition of shock, international interest rate shocks and currency crises are the most frequent shocks, while natural disasters, debt crises and political shocks are the rarest events. However, when considering the conditional frequency of observing an output collapse given that a particular shock materializes, debt crises and TOT shocks appear to be the most strongly associated with output collapses, while other types of shocks such as interest rate shocks are noisier and less informative of a subsequent output collapse. This can also be seen when looking at the noise-to-signal ratios, which is defined as the ratio between false-signal frequency (proportion of times that a shock signals a crisis without an output collapse occurring) to accurate-signal frequency (proportion of times that a shock signals correctly a crisis).

In Table 7, we test the effects on TFP associated with output collapses associated to the different types of shocks described above. In order to perform these tests, we associate a shock to a collapse when it takes place in a one-year window around that collapse.[24] Columns 1–4 present the tests for the four alternative counterfactuals considered in the present paper. There are interesting differences across types of shocks regarding the severity of the associated collapse as well as the degree of persistence of the effects on TFP, but in all cases the estimated effect on long-run TFP is negative.

For the first group, of rather exogenous shocks, TOT shocks, international interest rate hikes and oil price shocks are associated with a significant decline in TFP in three out the four counterfactuals. However, in the case of natural disasters, there is no significant impact on TFP. The magnitudes for TOT, interest rate and oil price shocks are quite similar, with point estimates for the TFP loss between 8 and 19%. Thus, we find that TFP fails to attain its pre-crisis path and, therefore, suffers permanent erosions. Although this evidence does not imply that TFP in always completely exogenous and that there are no feedback effects, for shocks primarily

[24] While this helps to increase the number of collapses for each test, it is reasonable given that there might be timing problems concerning the year to which a particular crisis/shock is assigned.

Table 7 Shocks, impact on TFP and expected foregone consumption loss

Type of shock	Linear model (1)	Country-specific absorption (2)	Country-specific trend with absorption (3)	Country-specific absorption with trend (4)	Prob. of event (5)	Expected loss (%) (6)
Terms of trade shock						
mean	−0.163	−0.152	0.005	−0.100	0.015	−3.78
p-value	0.01	0.00	0.93	0.04		
Interest rate shock						
mean	−0.150	−0.136	0.027	−0.083	0.016	−3.33
p-value	0.01	0.01	0.63	0.09		
Oil price shock						
mean	−0.192	−0.160	0.021	−0.107	0.008	−2.29
p-value	0.01	0.02	0.77	0.10		
Natural disaster						
mean	−0.469	−0.386	−0.274	−0.329	0.001	−1.17
p-value	0.20	0.15	0.28	0.16		
Systemic sudden stop						
mean	−0.259	−0.195	−0.168	−0.153	–	–
p-value	0.07	0.07	0.189	0.10		
Real currency shock						
mean	−0.160	−0.159	−0.067	−0.115	0.018	−5.48
p-value	0.00	0.000	0.142	0.004		
Nominal currency shock						
mean	−0.186	−0.196	−0.101	−0.153	0.013	−5.27
p-value	0.00	0.00	0.05	0.00		

Table 7 continued

Type of shock	Linear model (1)	Country-specific absorption (2)	Country-specific trend with absorption (3)	Country-specific absorption with trend (4)	Prob. of event (5)	Expected loss (%) (6)
Banking crisis						
mean	−0.178	−0.174	−0.099	−0.133	0.009	−3.17
p-value	0.00	0.00	0.04	0.00		
Debt crisis						
mean	−0.226	−0.230	−0.085	−0.176	0.007	−3.13
p-value	0.01	0.00	0.25	0.01		
Political shock						
mean	−0.346	−0.236	−0.180	−0.190	0.004	−2.03
p-value	0.00	0.00	0.02	0.01		
Internal war						
mean	−0.349	−0.361	−0.232	−0.316	0.006	−4.87
p-value	0.00	0.00	0.02	0.00		
No identified shock						
mean	−0.597	−0.247	−0.297	−0.185	–	–
p-value	0.08	0.16	0.18	0.23		
All						
mean	−0.222	−0.172	−0.074	−0.123	0.028	−9.06
p-value	0.00	0.00	0.04	0.00		

based on exogenous events there is a significant decline in TFP.[25] In this sense, collapses related to international financial market turmoil, have significantly negative effects on long-run TFP. Furthermore, some of the propagation of these shocks might be through large swings in the real exchange rate and triggering debt crises as the literature on sudden stops emphasizes (e.g. see Calvo and Talvi 2005).

Therefore, in the next line of Table 7, we focus on a related type of shocks, systemic sudden stops (3S), introduced by Calvo et al. (2006) (CIT hereafter). These episodes are defined as a sharp current account reversal (more than two standard deviations) that coincides also with a spike in the aggregate spread of sovereign bonds over Treasuries (measured by *JP Morgan's EMBI* spreads) for all emerging markets. The systemic nature of this type of shocks ensures the exogeneity of the underlying primary shock driving the output collapse.[26]

CIT focus on a group of emerging countries that are integrated to world capital markets and therefore potentially exposed to 3S events. Within this group they identify a sample of sixteen episodes of output collapses that occurred in the context of 3S as defined in their paper. Of these episodes, our sample includes only seven, primarily because CIT use a less stringent threshold for output drops than we do.[27] In the fifth row of Table 7, we analyze the evolution of TFP in the event of a 3S episode. According to our estimates, 3S episodes are associated with a subsequent decline in TFP similar in magnitude as for the other external shocks, but slightly larger (declines between 15 and 26%). Although the sample size is very small, these effects are significant again for three of the four counterfactual at a 10% level. Thus, in general TFP does not return to its counterfactuals in the aftermath of a 3S episode, such that with our metric, there is no Phoenix miracle for TFP.

For the next group of shocks, macroeconomic disturbances (large real and nominal depreciations, as well as banking and debt crises) that might be more endogenous and partially caused by the shocks analyzed above, we find that they are consistently associated with an economically and statistically significant decline in TFP in the aftermath of such a shock, with an estimated TFP loss with respect to the counterfactual of between 23 and 10%. Furthermore, political disturbances and civil wars have a particularly severe effect on TFP, about twice the size as the previously analyzed shocks. Of course, part of this effect might well be endogenous, in the sense that a previous deterioration in economic conditions (in particular TFP) might be one of the drivers of social unrest. Finally, the five episodes in our sample that are not associated with any of these types of shocks have only a transitory effect on TFP.

While exploring the particular mechanisms through which these different shocks affect TFP is beyond the scope of the paper, it is important to note that the evidence provided in this section allows us to make some causal connections between output

[25] Two-thirds of the episodes (47 out of the 75) are associated with at least one of these shocks.

[26] Of course, exogeneity of shocks does not imply that their impact does not interact with TFP levels, such that the final severity of the TFP collapse might well be reinforced by feedback effects. However, we analyzed the correlation between initial levels of TFP and the subsequent decline for each type of these shocks and did not find a significant correlation.

[27] These seven collapses are: Brazil 83, Chile 83, Mexico 95, Peru 83, Venezuela 83, Uruguay 83 and Thailand 98.

collapses caused by external events and the evolution of TFP. Next, we compare the different type of shocks from a welfare perspective.

5 The costs of productivity losses

In the previous sections we showed that output collapses are associated with persistent declines in aggregate productivity. In this section, we show that the costs of productivity drops in terms of expected GDP foregone can be substantial. Even if aggregate productivity recovers, the temporary productivity losses can be dear to the economy. Recovery from a collapse is a costly process that may require significant resource reallocation. Firms and entire sectors contract while others expand. Labor and capital is freed in some places to be used in others. All this transition may affect the aggregate efficiency of the economy until the process is completed. Therefore, even in the episodes in which aggregate TFP returns to its potential level the transition can be very costly. More so, of course, if recovery takes a long period of time or never fully materializes, as it appears to be the case on average in our sample.

The ex post welfare cost of output collapses can be measured as the consumption forgone due to the reduction in productivity. Since TFP enters as a multiplicative term in our production function (with an exponent equal to one), any reduction in TFP (in percentage terms) implies the same reduction in GDP and, for given factor accumulation, on consumption.[28] We will conservatively neglect welfare costs associated with lower factor accumulation on account of the lower returns brought by lower productivity as well as the decrease in investment due to more investment distortions, given that they do not have first-order effects on welfare.[29] However, it could be argued that given the low probability of these events, the ex ante welfare loss could be considerably lower.[30] In order to assess the *expected* welfare loss due to GDP collapses, we proceed as follows.[31] First, we use the frequency of episodes as an estimate of the probability of an episode. These probabilities of a collapse in the presence of the different shocks in a given year are presented in column 6 of Table 7.

Next, we compute the discounted present value of the difference between actual GDP and counterfactual GDP assuming that the differences between actual and counterfactual TFP levels estimated in Tables 6 and 7 are maintained in the future. This assumption does not appear particularly restrictive given our previous analysis and upon inspection of TFP trajectories (see the appendix in Blyde et al. (2008).

[28] The overall output foregone would amount to this direct output loss plus the indirect output foregone due to lower factor accumulation.

[29] This result follows directly from the envelope theorem.

[30] This argument would be in the spirit of Lucas (1987) who argues that welfare losses in the US due to business cycle fluctuations are small in economic terms.

[31] The estimate we are obtaining should be interpreted as the average expected output cost for a GDP collapse of similar characteristics to those observed in our sample.

Then, we discount this loss by a real rate of 4% per annum.[32] Thus, the expected loss is computed as:

$$p\sum_{t=0}^{\infty}\left(\frac{1}{1+r}\right)^{t}[\ln(\mathrm{TFP}_o)-\ln(\mathrm{TFP}_c)]=p\frac{1+r}{r}\ln\left(\frac{\mathrm{TFP}_o}{\mathrm{TFP}_c}\right), \tag{6}$$

where p is the probability of a collapse, r is the real interest rate, and the final term is the direct GDP loss incurred every year due to the difference between the observed level of TFP after the collapse and its counterfactual level. It should be pointed out that this is actually a lower bound of the ex ante welfare cost of growth collapses because we are not considering the indirect effects of a lower level of TFP on profitable factor accumulation, investment distortions, as well as transition costs. Equation (6) can be seen as the welfare cost for an agent with a period log-utility and lifetime present discounted utility given by:

$$\sum_{t=0}^{\infty}\beta^{t}\ln(C_t), \tag{7}$$

where β is the subjective discount factor and C consumption. Focusing on the steady-state values of consumption with a collapse or the observed consumption value (sub-index o) and the counterfactual (sub-index c), the welfare loss would be given by:

$$\sum_{t=0}^{\infty}\beta^{t}\ln(C_o)-\sum_{t=0}^{\infty}\beta^{t}\ln(C_c)=\frac{1}{1-\beta}\ln\left(\frac{C_o}{C_c}\right) \tag{8}$$

Imposing that $\beta = 1/(1+r)$ and that consumption in steady state is proportional to output (as the neoclassical growth model implied), we get that Eq. (8) multiplied by the probability of a collapse is equal to (6).[33]

The resulting magnitudes of multiplying this discounted present value by the probability of a collapse are presented in the last column of Table 7 for the different shocks. Overall, on average the welfare cost of collapses are economically significant. In terms of contemporaneous GDP, for the average output collapse implies an expected loss equivalent to 9% of GDP (see last row of the table). Furthermore, although output collapses associated to each of the different shocks are less likely to occur, the implied losses are still large. The rather exogenous external shocks to TOT, interest rates and oil prices imply a GDP loss of 2.3–3.8%, similar also to debt and banking crises (which are both less likely to occur, but more severe). Collapses associated to real and nominal depreciations, as well as civil wars twice as costly, around 5% of GDP.

Clearly, these magnitudes are large. It is interesting to point out that our conservative estimates are similar to the welfare costs of rare disasters estimated by Barro (2006). Even neglecting transition and investment effects and without considering risk aversion, our welfare estimates of output collapses are larger than

[32] Observe that for developed countries usually the standard discount rate is between 2 and 3%, such that our estimated welfare losses are rather conservative.

[33] Again, we are focusing here on first-order effects, leaving aside (based on envelope theorem considerations) the fact that factors would also react to changes in TFP.

the standard welfare costs of eliminating fluctuations in consumption in developing countries, which according to Pallage and Robe (2003) are equivalent to around 0.34% of permanent consumption in developing countries.[34]

TFP reduction is a pure welfare cost, permanent in the case of TFP destruction and transitory if TFP eventually recovers after a transition. As mentioned earlier, lower investment commanded by lower TFP would not entail a net welfare cost as a first-order approximation. Similarly, lower investment on account of additional distortions to the incentives to invest (e.g. higher risk of expropriation) would also generate only second-order welfare costs measured in terms of consumption. Nevertheless, lower investment would have a first-order impact on output level and growth, traditional measures of countries' performance. It may be interesting therefore to have a sense of the magnitude of investment effects on output and compare them with the pure productivity effect. However, as shown in Blyde et al. (2008), while output collapses sometimes have been accompanied also by a decline in investment ratios which could be linked to increases in investment distortions, the evidence on the latter is rather limited and its economic magnitude tends to be small.

6 Concluding remarks

In this paper we analyze the dynamics of TFP after output collapses and estimate the implied welfare losses. Using a large panel of developed and developing countries we find that almost all these collapses took place in developing countries.

We find strong evidence of persistent productivity destruction in Sub-Saharan Africa and in particular for Latin America and the Caribbean: the output collapses during the debt crisis in the 1980s meant more than a "lost decade" to the region. The evidence on the enduring impact of collapses on productivity for the other regions is somewhat weaker.

These long-term TFP shortfalls after output collapses are not merely a reflection of productivity weaknesses prompting both. When we constrain the sample to output collapses caused by exogenous shocks, we still find a similarly negative impact on TFP. In particular, global capital market disruptions and domestic shocks related to sudden stops (such as real exchange rate shocks) have the most destructive impact on TFP, as well as civil wars. The evidence suggests that there is irreversible productivity damage.

Our analysis also shows that the welfare costs of productivity losses can be very substantial. Permanent effects on productivity entail permanently lower GDP and lower long-term GDP growth. Even if effects are temporary and aggregate productivity recovers after a period of decline, the costs associated with the temporary but persistent losses in productivity can be large for the economy. A conservative estimation of welfare cost associated with the possibility of an output

[34] In our metric the present discounted value (using a discount rate of 5% also) of these costs would be around 4.8% points of GDP (assuming that consumption is around 70% of GDP), half of the estimated effect of a generic collapse.

collapse indicates that this contingency is more costly than the recurrent cost of business cycle fluctuations.

From a policy perspective, these large welfare costs associated with output collapses indicate the importance of focusing macroeconomic policies in developing and emerging economies on crisis prevention and risk management rather than reducing business cycle fluctuations. This paper suggests that there is a big premium on prudent policies against the risk of an extreme output downfall, given that policies able to prevent a crisis could have an important impact on long-term output levels.

Finally, it is worth noticing that the prevalence of output collapses in Latin America and developing countries in general contributes to low long-run growth and lack of convergence. In fact, a conservative estimate implies that on average persistent productivity reductions after an output collapse lower GDP levels by around 12% compared to its counterfactual. Even without any additional deterioration from investment distortions, such a reduction every 33 years (the observed frequency of output collapses) amounts to an average reduction of 0.4% points of GDP per worker growth per annum.

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Appendix

See Table 8

Table 8 Sample

Algeria	Hong Kong	Panama
Argentina	Hungary	Papua New Guinea
Australia	India	Paraguay
Austria	Indonesia	Peru
Belgium	Iran	Philippines
Benin	Ireland	Portugal
Bolivia	Israel	Senegal
Brazil	Italy	Sierra Leone
Cameroon	Jamaica	Singapore
Canada	Japan	South Africa
Chile	Jordan	Spain
China	Kenya	Sri Lanka
Colombia	Korea	Sweden
Costa Rica	Lesotho	Syria
Denmark	Malawi	Thailand
Dominican Republic	Malaysia	Togo

Table 8 continued

Ecuador	Mali	Tunisia
Egypt	Mexico	Turkey
El Salvador	Mozambique	Uganda
Fiji	Nepal	United Kingdom
Finland	Netherlands	United States
France	New Zealand	Uruguay
Germany	Nicaragua	Venezuela
Ghana	Niger	Zambia
Greece	Norway	
Honduras	Pakistan	

References

Aghion, P., & Saint-Paul, G. (1998). On the virtues of bad times: An analysis of the interaction between productivity growth and economic fluctuations. *Macroeconomic Dynamics, 2*(3), 322–344.

Aguiar, M., & Gopinath, G. (2007). Emerging market business cycles: The cycle is the trend. *Journal of Political Economy, 115*(1), 69–102.

Bai, J., & Perron, P. (1998). Estimating and testing linear models with multiple structural breaks. *Econometrica, 66*(1), 47–78.

Bai, J., & Perron, P. (2003). Computation and analysis of multiple structural change models. *Journal of Applied Econometrics, 18*(1), 1–22.

Barro, R. J. (2006). *On the welfare costs of consumption uncertainty*, (*NBER Working Papers* 12763). Cambridge, MA: National Bureau of Economic Research.

Barro, R. J., & Lee, J.-W. (2000). *International data on educational attainment: Updates and implications*, (*CID Working Paper* 42). Cambridge, MA: Harvard University.

Becker, T., & Mauro, P. (2006). *Output drops, and the shocks that matter*, (*IMF Working Paper* WP/06/172). Washington, DC: International Monetary Fund.

Bell, J., & Pain, D. (2000). *Leading indicators of banking crises: A critical review*, *Financial Stability Report 9*, Bank of England, pp. 113–129.

Berg, A., Ostry, J. D., & Zettelmeyer, J. (2006). What makes growth sustained? Paper Presented at the 2006 IMF conference "Economic Growth and Latin America: what have we learned?".

Bergoeing, R., Loayza, N., & Repetto, A. (2004). Slow recoveries. *Journal of Development Economics, 75*(2), 473–506.

Blyde, J.S., Daude, C., & Fernández-Arias, E. (2008). *Output collapses and productivity destruction*, (*Working Paper* 666). Washington, DC: Research Department, Inter-American Development Bank.

Blyde, J.S., & Fernández-Arias, E. (2005). Why Latin America is falling behind. In E. Fernandez-Arias, R. E. Manuelli, & J. S. Blyde (Eds.), *Sources of growth in latin America: What is missing?* Washington DC: Inter-American Development Bank.

Caballero, R. J., & Hammour, M. L. (1994). The cleansing effect of recessions. *American Economic Review, 84*, 1350–1368.

Caballero, R. J., & Hammour, M. L. (2005). The cost of recessions revisited: A reverse-liquidationist view. *Review of Economic Studies, 72*(2), 313–341.

Calvo, G., Izquierdo, A., & Talvi, E. (2006). Sudden stops and phoenix miracles in emerging markets. *American Economic Review Papers and Proceedings, 96*(2), 405–410.

Calvo, G., & Talvi, E. (2005). *Sudden stop, financial factors and economic collapse in Latin America: Learning from Argentina and Chile*, (*NBER Working Paper* 11153). Cambridge, MA: National Bureau of Economic Research.

Caprio, G., & Klingebiel, D. (2003). *Episodes of systemic and borderline financial crises*. Mimeo, World Bank, Washington, DC.

Caselli, F. (2005). Accounting for cross-country income differences. In P. Aghion & S. Durlauf (Eds.), *Handbook of Economic Growth* (Vol. 1, Part 1, pp. 679–741). Amsterdam: North Holland.

Cerra, V., & Saxena, S. C. (2008). Growth dynamics: The myth of economic recovery. *American Economic Review, 98*(1), 439–457.

Chari, V. V., Kehoe, P., & McGrattan, E. (2007). Business cycle accouting. *Econometrica, 75*(3), 781–836.

Daude, C., & Fernández-Arias, E. (2010). *On the role of productivity and factor accumulation for economic development in Latin America and the Caribbean*, (*IDB Working Paper* 155). Washington, DC: Inter-American Development Bank.

Demirgüç-Kunt, A., & Detragiache, E. (2005). *Cross-country empirical studies of systemic bank distress: A survey*, (*IMF Working Papers* WP05/96). Washington, DC: International Monetary Fund.

Detraigiache, E., & Spilimbergo, A. (2001). *Crises and liquidity: Evidence and interpretation*, (*IMF Working Paper* WP/01/2). Washington, DC: International Monetary Fund.

Drazen, A., & Easterly, W. (2001). Do crises induce reform? Simple empirical tests of conventional wisdom. *Economics and Politics, 13*(2), 129–157.

Easterly, W., & Levine, R. (2001). It's not factor accumulation: Stylized facts and growth models. *World Bank Economic Review, 15*(2), 177–219.

Em-Dat. (2009). *The International Disaster Database*, Centre for Research on Epidemiology of Disasters—CRED, www.em-dat.net Accessed October 2009.

Fernández-Arias, E., Panizza, U., & Stein, E. (2002). *Trade agreements, exchange rate disagreements*. Mimeo, Inter-American Development Bank, Washington, DC.

Grossman, G. M., & Helpman, E. (1991). *Innovation and growth in the global economy*. Cambridge, Massachusetts: MIT Press.

Hall, J., & Jones, C. (1999). Why do some countries produce so much more output per worker than others? *Quarterly Journal of Economics, 114*(1), 83–116.

Hausmann, R., Pritchett, L., & Rodrik, D. (2005). Growth accelerations. *Journal of Economic Growth, 10*(4), 303–329.

Hausmann, R., Rodriguez, F., & Wagner, R. (2006). *Growth collapses*, (*Center for International Development Working Paper* 136), October. Cambridge, MA: Harvard University.

Hong, K., & Tornell, A. (2005). Recovery after a currency crisis: some stylized facts. *Journal of Development Economics, 76*(1), 71–96.

Im, K., Pesaran, H., & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics, 115*(1), 53–74.

Jones, B. F., & Olken, B. A. (2008). The anatomy of start-stop growth. *Review of Economics and Statistics, 90*(3), 582–587.

Kaminsky, G. L., & Reinhart, C. M. (1999). The twin crises: The causes of banking and balance-of-payments problems. *American Economic Review, 89*(3), 473–500.

Kehoe, T. J., & Prescott, E. C. (Eds.). (2007). *Great depressions of the twentieth century*. Minneapolis: Federal Reserve Bank of Minneapolis.

Laeven, L., & Valencia, F. (2008). *Systemic banking crises: A new database*, (*IMF Working Paper* 08/250). Washington, DC: International Monetary Fund.

Levin, A., Lin, C.-F., & Chu, C.-S. J. (2002). Unit root tests in panel data: Asymptotic and finite sample properties. *Journal of Econometrics, 108*(1), 1–24.

Lucas, R. E. (1987). *Models of business cycles*. New York: Basil Blackwell.

Maddala, G. S., & Wu, S. (1999). A comparative study of unit root tests with panel data and a new simple test. *Oxford Bulletin of Economics and Statistics, 61*(4), 631–652.

Manasse, P., & Roubini, N. (2005). *'Rules of thumb' for Sovereign debt crises*, (*IMF Working Papers* WP/05/42). Washington, DC: International Monetary Fund.

Martin, P., & Rogers, C. A. (1997). Stabilization policy, learning-by-doing, and economic growth. *Oxford Economic Papers, 49*(2), 152–166.

Pallage, S., & Robe, M. A. (2003). On the welfare cost of economic fluctuations in developing countries. *International Economic Review, 44*(2), 677–698.

Parente, S., & Prescott, E. C. (2000). *Barrier to riches*. Cambridge, Massachusetts: MIT Press.

Parente, S., & Prescott, E. C. (2005). A unified theory of the evolution of international income levels. In P. Aghion & S. Durlauf (Eds.), *Handbook of Economic Growth* (Chap. 21, pp. 1371–1141). Rotterdam: North-Holland.

Pesaran, H. (2003). A simple panel unit root test in the presence of cross section dependence, (*Cambridge Working Papers in Economics* 0346), Faculty of Economics (DAE), University of Cambridge.

Pritchett, L. (1997). Divergence, big time. *Journal of Economic Perspectives, 11*(3), 3–17.

Pritchett, L. (2000). Understanding patterns of economic growth: searching for hills among Plateaus, Mountains, and Plains. *World Bank Economic Review, 14*(2), 221–250.

Ranciere, R., Tornell, A., & Westermann, F. (2008). Systemic crises and growth. *Quarterly Journal of Economics, 123*(1), 359–406.

Reinhart, C. M., Rogoff, K. S., & Savastano, M. A. (2003). Debt intolerance. *Brookings Papers on Economic Activity, 1*, 1–62.

Restuccia, D., & Rogerson, R. (2008). Policy distortions and aggregate productivity with heterogeneous plants. *Review of Economic Dynamics, 11*(4), 707–720.

Romer, P. (1990). Endogenous technological change. *Journal of Political Economic, 98*(5), 71–102.

Tommasi, M., & Velsco, A. (1996). Where are we in the political economy of reform? *Journal of Policy Reform, 1*(2), 187–238.

Uhlig, H., & Ravn, M. (2002). On adjusting the HP-filter for the frequency of observations. *Review of Economics and Statistics, 84*(2), 371–376.