The Fiscal Cost of Trade Liberalization*

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Abstract

Trade taxes are an important source of revenue for developing countries. These revenues have fallen over the past decades as these countries liberalized trade. Many developing countries simultaneously experienced a decrease in their total tax revenues, suggesting trade liberalization may have come at a fiscal cost. Using a novel panel dataset of tax revenues and government expenditures in developing countries for the period 1945-2006 we identify 110 episodes of decreases in tariff revenues and consider whether countries are able to recover those lost revenues through other tax resources. We show that trade taxes fall by close to 4 GDP percentage points on average during those episodes. Less than half of the countries recover the lost tax revenues 5 years after the start of the episode. The picture is similar when we consider government expenditures. We use the intuition that pre-existing tax capacity is needed to levy domestic taxes to explain theoretically why some countries are unable to recover all tax revenues lost from lowering tariffs. We find that the fiscal cost of trade liberalization is a non-linear function of countries' incentives to invest in tax capacity, and that some will be stuck in a low tax capacity trap. Finally we provide some empirical evidence in line with the model's predictions.

JEL classifications: H10, H20, F13, O17

Keywords: Taxation and development, Trade liberalization, State capacity, Tax and tariff reform

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"*It's far easier to levy a tariff than to collect value added tax. You just need a guy at the border... But as more and more countries join the World Trade Organisation (WTO) they join in the commitment to reduce tariffs.*" (Jeffrey Owens, 2008)[1]

1 Introduction

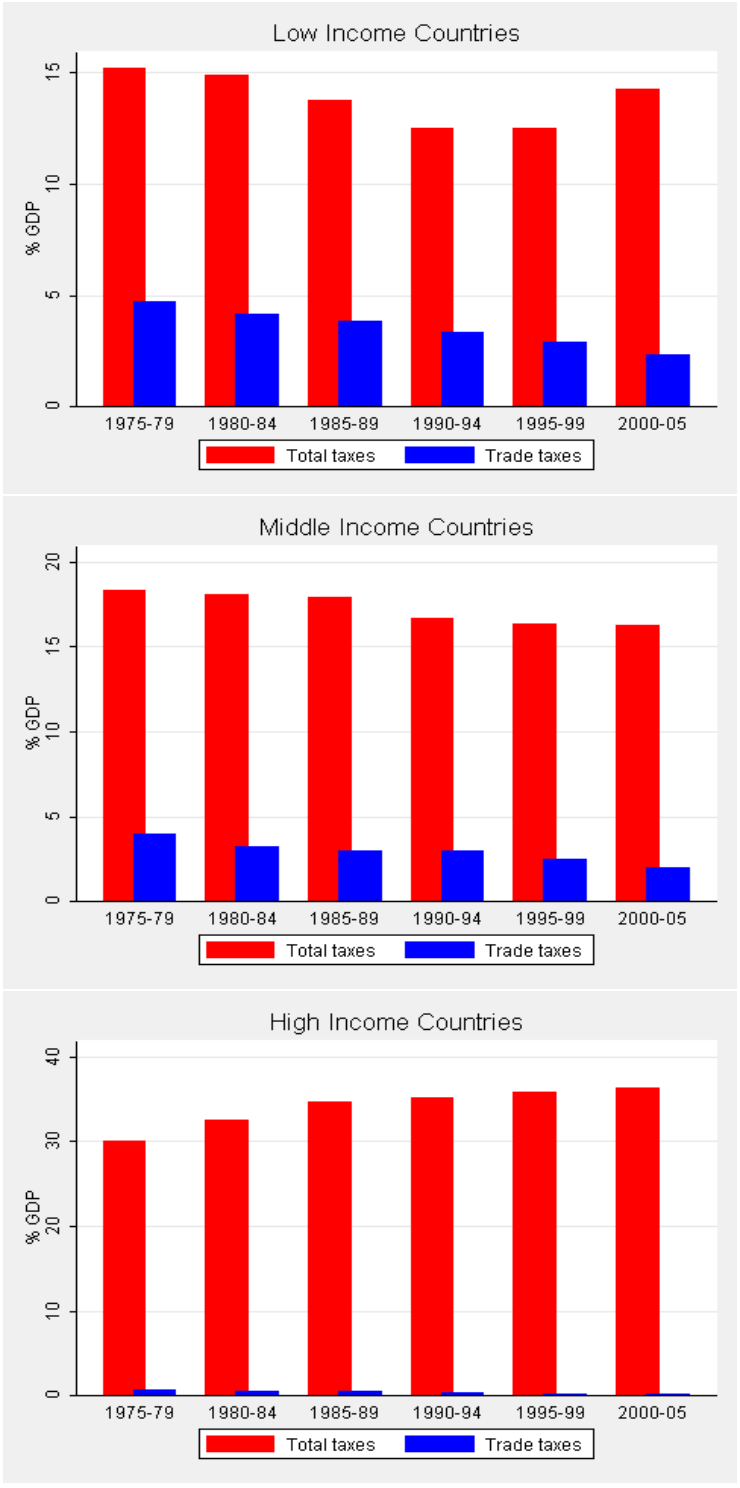
When Robert Peel implemented one of Great Britain's first large over-the-board decrease in tariffs in 1842 over a third of tax revenues in the country came from export and import duties. This budget overhaul was financed by the re-introduction of the income tax and the mobilization of the modern tax bureaucracy built during the Napoleonic Wars. The extra tax revenue raised was more than expected, allowing for further tariff reforms and the famous repeal of the Corn Laws in 1846 (Bairoch, 1989). This episode is but one example of a general historical pattern. In the first stage of industrialization now-developed countries relied heavily on tariffs to provide tax revenues. They gradually lowered them once they had developed a fiscal administration which made it possible to raise tax revenues through other means (Ardant, 1972). Developing countries have similarly greatly decreased their tariffs over the last 40 years, often pressured by international organizations and trading partners. However little attention has been paid to the question of whether the fall in tax revenues implied by this decrease was compensated for through other tax resources.

The evolution of trade tax and total tax revenues from 1975 to 2005 suggests that the decrease in tariffs was accompanied by a fall in total tax revenues in developing countries. In Figure 1 we plot separetely for low income countries (LICs), middle income countries (MICs) and high income countries (HICs) the evolution between 1975 and 2005 of total and trade tax revenues as a share of GDP. At the start of the period tariff revenues are a major source of public resources in countries at lower levels of development. They are a third of total tax revenues (nearly 5% of GDP) in LICs, a fifth in MICs and less than 2% in HICs.

Revenues from trade taxes decrease as a share of GDP in all country groups over the period with very different consequences on total tax revenues. In poorer countries they fall by 2 GDP percentage points between 1975 and 2000. There is a simultaneous fall in total tax revenues of the same magnitude. Not until the last period (2000-2005) do we see an increase in total tax revenues, which nevertheless remain lower than in 1975. Similarly MICs also loose 2 GDP percentage points of trade and total tax revenues over the period 1975-2000. The contrast with the experience in HICs is striking. Revenues from tariffs in rich countries are today a third of what they were in the 1970s but this has clearly been compensated by an increase in collection of domestic taxes, with total taxes increasing from 30% to 36% of GDP. Overall Figure 1 shows a 13% fall in tax revenues in developing countries between 1975 and 2000 and suggests that this decrease was a consequence of a fall in trade tax revenues.

[1] Statement by Jeffrey Owens, director of the Center for Tax Policy Administration at the Organisation for Economic Cooperation and Development, December 2008 (Reuters).

Figure 1: Evolution of tax revenues as a share of GDP, 1975-2005



All values are median values for the country group and time period considered. The sample includes in each time period 26 low income countries, 40 middle income countries and 32 high income countries. See Appendix A for the list of countries included in our sample and Appendix C for a description of the variables.

These trends are not driven by higher growth in less developed countries over the period. Appendix Figure 5 presents the evolution of trade tax and total tax revenues *per capita* over the period and paints a similar picture. The divergence between rich and poor countries is even more noticeable when put in per capita terms. Whilst tax revenues per capita more than double in rich countries they halve in the least developed ones.

This paper's first contribution lies in its comprehensive empirical account of the fiscal consequences of trade liberalization. We construct a novel dataset of tax revenues in 103 developing countries for the period 1945-2006 from different historical and contemporary sources. To the best of our knowledge this is the most exhaustive existing dataset on tax revenues in developing countries. We develop a method to detect large and prolonged downward shocks in tariff revenues – which we call 'episodes' – and their impact on total tax revenues. We identify 110 such episodes in which countries experience a more than 1 GDP percentage point fall in tariff revenues. We say that countries 'recover' fiscally when their total tax revenues is at least equal to its level at the start of the episode.

We find that trade tax revenues fall by nearly 4 GDP percentage points on average during those episodes, a fall equivalent to 20% of total tax revenues. More than half of the countries suffer an immediate loss in total tax revenues contemporaneous to the fall in trade tax revenues. This loss persists in the medium-run: ten years later 45% of these countries have not recovered all lost tariff revenues through other sources of taxation. The picture is very similar if we consider the evolution of government expenditures. Nearly half of the countries which experienced a large fall in trade tax revenues also experienced a simultaneous fall in their total revenues and expenditures which persisted for at least ten years.

Our second contribution is to explain theoretically why some countries recover the lost trade tax revenues through domestic taxation and some do not. The model is build on the intuition that countries at an early stage of development rely on trade taxes for revenues because these taxes do not require much tax administration – or tax capacity – to be levied, as opposed to domestic taxes such as the income tax or the VAT. We define tax capacity as a government's ability to accurately observe and monitor economic transactions on its territory and take away some of these transactions for its own use. Formally, we build on the theoretical framework constructed by Besley and Persson (2009) which explains in which conditions a state will choose to invest in its state capacity in order to increase its revenue raising powers in the future. We add to this framework the possibility for the state to use a tariff which requires no pre-existing capacity to be levied. This fiscal choice is embedded in a simple trade model in which domestic taxes are lump-sum and tariffs are distortive. Endogenous investments in tax capacity alter a country's choice of tax mix and openness to trade over time, in line with the key stylized facts regarding taxation and development that we present. Total tax revenues increase over time, and the ratio of tariffs to domestic taxes decreases.

We then consider the fiscal consequences of a permanent (exogenous) fall in tariff revenues. Our main result is that countries faced with low returns to tax investments are stuck in a 'low tax capacity trap': they will suffer a permanent

fall in tax revenues after the fall in tariffs. In all other countries the fall actually increases incentives to invest in raising future tax revenues and thus hastens the transition towards a more efficient tax mix. It leads to a short-run revenue loss and a gradual recovery that happens faster the higher the returns to tax investments and the demand for public goods.

Two policy implications stem from our model. First, we show that trade liberalization comes at a fiscal cost. This cost could erode support for further trade liberalization but can be overcome by technical investments in tax capacity building. Second, increasing developing countries' tax capacity will lead them to open to international trade: technical aid in resource mobilization will trigger a decrease in tariffs.

We test the model's predictions using our sample of trade liberalization episodes. We find that countries' characteristics at the time of the shock help explain their future capacity to recover lost trade tax revenues. To proxy for the ease with which tax capacity can be increased we use population density – income and consumption taxes are harder to levy in sparsely populated areas –, the share of agriculture in GDP – a likely correlate of the size of the informal sector – and capital account openness, which makes tax evasion harder to fight. We find that countries with a more tax friendly economic environment thus measured recover the lost tax revenues faster. We also provide a test of the predictions in Besley and Persson (2009) that democratic countries and those at war will invest more in tax capacity. We find that more democratic countries are more likely to recover the lost trade tax revenues through increases in domestic taxation and some evidence that experiencing a war increases the likelihood of recovery in the medium-run.

This paper's implicit normative assumption is that a sustained 20% fall in tax revenues is welfare decreasing. It constrains public good provision in countries which, for most of the period under consideration, were characterized by unsustainable debt levels and faced with major public investment challenges. Our goal is not to enter the debate regarding the efficiency (or lack theoreof) of public spending in developing countries, nor to provide a complete general equilibrium analysis of the welfare impact of trade liberalization. However we note that increasing domestic revenue mobilization has long been a central element of the development strategies of both the international community and many low income countries (Sachs et al., 2005, Gupta and Tareq, 2008, OECD, 2010). In most of our discussion we take as given that developing countries use tax revenues to finance welfare enhancing public spending.[2]. Our predictions regarding which countries are likely to recover the taxes lost due to trade liberalization nevertheless remain the same when we consider the case of a non-benevolent government in an extension to the model.

The topic of this paper is closely related to the work of Baunsgaard and Keen (2010) that first points out the potential fiscal cost of trade liberalization. Using 25 years of panel data they estimate how domestic tax revenues react to changes in trade tax revenues in the short-run. They show that there has only

[2]This is consistent with a recent literature that points out that differences in capacity to tax lead to persistent differences in growth rates or the quality of public provision (Aizenman and Jinjarak, 2007, Aghion, Akcigit, Cagé, and Kerr, 2011, Gadenne, 2011). On the importance of state capacity for development see also Acemoglu (2005).

been incomplete replacement of lost trade tax revenues in low-income-countries. Our approach furthers their analysis of the fiscal consequences of trade liberalization in three important dimensions. First our use of a longer and more complete dataset allows us to generalize our results to the entire tax history of developing countries since independence. Second our empirical method abstracts from short-term co-movements between domestic tax and tariff revenues which may be unrelated to structural changes in reliance on trade as a tax handle. This allows us to identify the impact of trade liberalization on total tax revenues in the short- and medium-run. Finally, we explain theoretically the variety of countries' fiscal experiences we observe in the data.

Our theoretical framework is a close cousin of that developed by Besley and Persson (2009, 2010, 2011) which we extend to the choice of tax mix in an open economy. We thus contribute to the nascent literature on tax capacity by providing a first application of this concept to the recent history of developing countries and to a question of immediate relevance to policy makers.

The model outlined in this paper also complements the theoretical literature on the choice of optimal tax mix. Keen and Ligthart (2002) show that in a standard optimal taxation model replacing tariff revenues is efficiency improving, as tariffs are more distortive than domestic taxes. Several authors have mitigated this benchmark result suggesting that this change in tax mix may not be unambiguously welfare-improving in the presence of market imperfections (Keen and Ligthart, 2005, Naito, 2006) or a large informal sector (Emran and Stiglitz, 2005). We go one step further by showing that replacing tariffs with domestic taxes can only be done in countries which are willing to incur the cost of augmenting their capacity to tax domestically.

This paper is finally related to the literature that studies how the specific constraints faced by developing countries explains their tax mix. Riezman and Slemrod (1987) show that countries facing higher tax collection costs rely more heavily on tariffs because they are easy to levy (see also Aizenman (1987) for a theoretical approach to this question). Easterly and Rebelo (1993) find that larger countries rely more heavily on the income tax than on trade taxes because the former has larger setup bureaucratic costs. We build on these results by endogenizing (domestic) tax collection costs through the introduction of investments in tax capacity. A similar approach is taken by Cukierman, Edwards, and Tabellini (1992) who show how the use of a suboptimal tax instrument (seignorage) depends on the efficiency of the tax system and model the latter as the outcome of a strategic choice by governments. Kleven, Kreiner, and Saez (2009) offer an alternative theoretical explanation of why developing countries rely little on taxes with a large domestic base such as the income tax or the VAT. Their model is however silent regarding how economic development affects the choice of tax mix. Finally there is a growing empirical literature on how developing countries can increase tax collection through improvements in tax administration (Piketty and Qian, 2009, Pomeranz, 2010, Gadenne, 2011).

The outline of the paper is as follows. Section 2 describes the data and method we use and presents the key facts regarding the extent of recovery of lost trade tax revenues through domestic sources of taxation. Section 3 provides historical motivating evidence for the idea that countries at an early stage of development need to rely on tariffs for revenues and will lower them once they

have built sufficient tax capacity. Section 4 outlines the model built around this idea and key predictions regarding the fiscal cost of trade liberalization. Section 5 tests these predictions using our sample of episodes of tariff declines. We conclude with Section 6.

2 The fiscal consequences of trade liberalization

2.1 Data

We collect data on total and trade tax revenues from three different sources. For the period 1975-2006 we use the tax database built by Baunsgaard and Keen (2010) which covers 117 countries and was constructed using the revenue information provided by the IMF's periodic consultations with member countries. We complete this dataset for the period 1972-1975 and for missing countries by using data from the *Government Finance Statistics* and the *Historical Government Finance Statistics* (IMF). For the 1945-1971 period we use data from Mitchell (2007). More information on the construction of this dataset is provided in Appendix C.

We obtain an unbalanced dataset on total tax revenues and trade tax revenues for 117 countries between 1945 and 2006.[3] For the purpose of our analysis we exclude all countries which never levy more than 1% of GDP in trade taxes in the post 1975 data, since our 'shocks' on tariff revenues are defined as at least a 1 GDP percentage point fall in tariff revenues. This excludes most developed countries from our sample. We are left with a sample of 103 developing countries. To the best of our knowledge this is the most complete existing dataset on tax revenues in developing countries combining historical and contemporary data. We scale these tax volumes by both population and GDP. Our key results are obtained using trade tax and total tax revenues as a share of GDP. We discuss robustness using per capita variables as well.

A fall in tax revenues may not lead to a decrease in a country's capacity to provide public goods if it is compensated for by an increase in non-tax revenues, such as revenues from the exploitation of natural resources by a public monopoly or development aid. A more direct measure of a country's capacity to provide public goods is its public expenditure to GDP ratio. Data on government expenditures is less readily available than data on tax revenues, yet we seek to complete our dataset by collecting data on government expenditures from the *Government Finance Statistics*, the *Historical Government Finance Statistics* and Mitchell (2007). This covers 80 of our 103 developing countries.

2.2 Episodes of decreases in tariff revenues and extent of revenue recovery

Method

We identify episodes of decreases in tariff revenues by defining 'shocks' to

[3] We exclude 18 countries for which our series is too short (less than 15 years) to identify medium-run impacts of decreases in trade tax revenues. This excludes mostly countries from the ex-Soviet block.

trade tax revenues. To ensure that our definition of episodes is not affected by noisy variations in our data, we apply the Hodrick-Prescott (HP) filter method to smoothed tax series.[4] A fall in trade taxes is considered an episode if there is at least a 1 GDP percentage point fall in tariff revenues between a local maximum (which we call the start year s) and the following local minimum. Our results are robust to defining an episode by at least a 2 GDP percentage points fall in tariff data. However since – by construction – the higher the threshold, the lower the number of episodes, our favorite specification is the one with at least a 1 GDP percentage point fall. We choose to work with episodes rather than just studying how total tax revenues vary with trade tax revenues because detecting large downward shocks in tariff revenues allows us to abstract from potentially noisy short-term movements and consider the medium-run fiscal cost of trade liberalization.

We define the magnitude of the episode as the difference in trade tax revenues between the date of the local maximum (year s) and the date of the following local minimum. The length of the episode is the number of years between the local maximum and the following minimum. To measure the fiscal consequences of these shocks we use the data on total tax revenues. We compare tax revenues in each year after the start of the episode to their value in the year s in which the episode starts. We say that a country experiences a recovery when total tax revenues are equal to, or higher than, the value in year s. There is therefore 'no recovery' in a country if the episode leads to a fall in tariff revenues which is never compensated for by an increase in other tax revenues. We use the same method to study the impact of these shocks on government expenditures.

Figure 3 illustrates graphically how we construct the episodes and define recovery, using the example of Guatemala for which we have data for the period 1972-2004. The vertical dashed red line represents the start of the episode which corresponds to a local maximum for the smoothed trade tax revenue series. The episode starts in 1977 and trade tax revenues fall by 2.4 GDP percentage points between 1977 and 1984. It is driven by a fall in tariffs: we observe a 25% fall in the average tariff rate after 1977 compared to the average level during the 1970s (see Section 2.3 below for an investigation of the causes of the episodes). The vertical blue line corresponds to the year of the recovery, the first date at which total tax revenues come back to the level to which they were at the start of the episode. This happens in 2002: Guatemala took 25 years to recover from this episode.

Results

86 countries experience at least one episode of tariff revenue decline over the period and 24 countries experience 2 episodes. Our sample for most of the analysis in this paper includes therefore 110 episodes listed in Appendix D. Most took place in the 1970s (37 episodes) or the 1980s (38). Only 6 countries experienced a shock before 1970 – this may be driven by the fact that our sample size is much smaller before 1970 due to data availability. 29 episodes occurred in the period 1990-2006.

[4] We use a HP filter with a standard smoothing parameter of 6.25. Our results are robust to modifying this parameter.

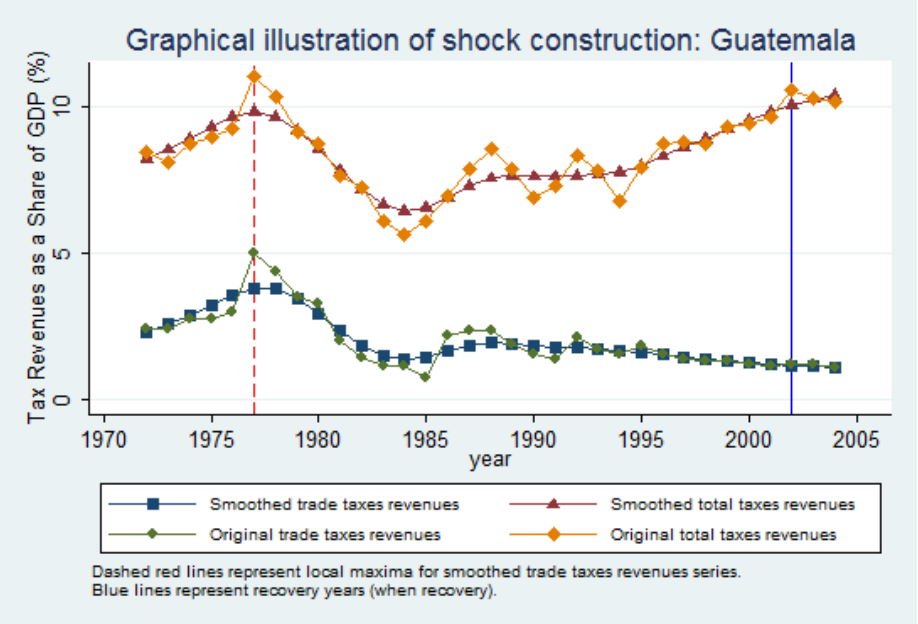


Figure 3: Guatemala

Table 1 presents the key characteristics of these episodes. The decreases in tariff revenues are substantial: 3.8 GDP percentage points on average, over half the amount of tariff revenues collected at the start of the episode (7.4% of GDP). This corresponds to a 20% fall in total tax revenues. The magnitude of the episodes ranges anywhere between 4% of total tax revenues (Tunisia in 1983) and 60% (The Gambia in 1985). Countries are on average not able to compensate for this loss of tariff revenues by an increase in other sources of taxation: 55% of them suffer an immediate loss in total tax revenues and 45% have not completely recovered the lost revenues 10 years after the shock.[5] Moreover, 28% of the episodes lead to a fall in total tax revenues which, as far as we can tell from our sample, is permanent: we observe these countries for more than 20 years on average. Finally, countries which did recover took on average 5.7 years to do so.

The picture is similar when we consider government expenditures. Shocks on trade tax revenues lead to a sustained decrease in government expenditures that countries are on average not able to compensate for. 60% of the countries suffer an immediate loss in government expenditures and more than 40% of them have not come back to their initial level of expenditures 10 years after the shock.

Robustness

Our method for the identification of episodes is potentially vulnerable to shocks

[5]This number is calculated excluding the two countries which we do not observe for at least 10 years after the start of the episode.

Table 1: Descriptive statistics on episodes of tariff revenue declines

	Mean	SD	Nb obs
Time of shock	1982.5	9.1	110
Size of the episode (% GDP)	3.8	2.9	110
Tariff revenues (%GDP)	7.4	5.2	110
Tax revenues (%GDP)	19.9	9.3	110
Size of the episode (% tax revenues)	20.3	12.4	110
Share that recovers after 1 year	44.5	49.9	110
Share that recovers after 5 years	48.2	50.2	110
Share that recovers after 10 years	55.5	49.9	110
Time to recovery (years)	5.7	7.4	79
If no recovery, potential recovery time (years)	21.2	5.7	31
Share that recovers after 1 year (expenditure)	40.0	49.3	75
Share that recovers after 5 years (expenditure)	47.9	50.3	71
Share that recovers after 10 years (expenditure)	57.4	49.8	68

to GDP which would affect the tax-to-GDP ratios we consider even if tax revenues are unchanged. An alternative that still allows for meaningful comparison between countries is to consider the evolution of tax revenues per capita. We therefore use a second method which defines an episode as a fall of at least 25% in tariff revenues per capita between a local maximum and the following local minimum. We choose the 25% threshold to obtain a number of shocks close to that obtained using the first method. All our results are robust to the use of a 30% threshold.

Table 2 presents the summary statistics for the 131 shocks obtained when we use this definition. They are on average bigger than episodes found using the first definition. They represent a 40% fall in total tax revenues per capita. However what is striking from Table 2 is that the share of countries which recover is extremely similar to that in Table 1 for both immediate and medium-run recovery. This remains true if we vary the threshold used to define a shock: descriptive statistics of the episodes identified using a 30% fall in trade taxes per capita or a 2 GDP points fall in trade taxes scaled by GDP are available in the paper's online Appendix. The key picture that emerges from our data is therefore robust to different definitions of what constitutes an episode of large decrease in tariff revenues. Roughly half of the countries suffer a short-term loss in total tax revenues when their tariff revenues fall, and this loss lasts for more than 10 years for the majority of them.

Looking for a fiscal 'recovery' after a fall in trade taxes is inappropriate if this fall has been anticipated. Countries may decide to increase domestic taxation before lowering tariffs precisely to counterbalance for the coming fall in trade tax revenues. The level of domestic tax revenues we observe at the start of the episode would then already compensate the anticipated loss in tariff revenues. We consider this possibility by examining the evolution of domestic taxes in the 5 years preceding the start of the episode. In 7 of our 110 cases we observe an increase in domestic taxes at least as large as the fall in trade taxes during the

Table 2: Descriptive statistics on episodes of tariff revenue declines, per capita definition

	Mean	SD	Nb obs
Time of shock	1984.5	8.3	127
Size of the episode (% GDP)	61.7	23.0	127
Tariff revenues per capita	127.4	184.8	127
Tax revenues per capita	606.7	1193.1	127
Size of the episode (% tax revenues)	41.2	47.6	127
Share that recovers after 1 year	48.0	50.2	127
Share that recovers after 5 years	50.4	50.2	125
Share that recovers after 10 years	58.9	49.4	124
Time to recovery (years)	4.7	7.2	87
If no recovery, potential recovery time (years)	20.4	6.8	40

episode. This could indicate an anticipation of the decline in tariffs. We discuss below the robustness of our empirical results to excluding these episodes from our sample.[6]

2.3 Why did trade taxes decrease?

Trade liberalization is not the only possible cause of decreases in tariff revenues. It could also be a consequence of a fall in trade volumes or a shock to the exchange rate. More worrying for our analysis a major destructive event (a large war or a natural catastrophe) may lead to a simultaneous collapse in trade and domestic tax collection, making no recovery of the lost trade tax revenues trivially the only possible outcome. Using data on tariffs, trade volumes, exchange rates and dates of entry in regional and international trade agreements, we propose a typology of the causes of the episodes. An episode for which the country is seen to enter a free trade agreement the year the episode starts or during the following 3 years is defined as being a consequence of trade liberalization. Breaks in tariff revenues, trade volumes or exchange rates around the start year are similarly identified as potential 'causes' of the episodes. Appendix D gives the cause of each episode that we identify.

We find that nearly 60% of the episodes are associated with a move towards greater trade liberalization, because of entry in a free trade agreement (36% of the episodes) or a fall in tariff rates (21%). Another 14% experienced a clear fall in either exports or imports and 6% an exchange rate shock. 26 episodes remain for which we cannot identify any clear cause of the shock – in most cases because we do not have any data on potential sources of shocks. We turn to the political history of these countries to help explain the cause of the fall in trade taxes. Some, like Cameroon in the 1970s, embarked on economic liberalization reforms which included lowering barriers to trade. Others, like Namibia in 1985, experienced serious political unrest or civil wars which may explain why tariff revenues collapsed. We restrict our empirical analysis to episodes which

[6]Descriptive statistics in Table 2 are very similar if we exclude these episodes.

are caused by trade liberalization, a shock in exchange rates or a fall in trade volumes as a robustness check.

3 Historical background: tax capacity and the tax transition in now developed countries

Our model in Section 4 builds on the assumption that domestic sources of taxation such as the income tax or the VAT require more tax capacity to be levied than trade taxes. This implies that countries at early stages of development with low tax capacity rely on trade taxes as a source of revenues and gradually build tax capacity until they have enough to only use domestic taxes. This assumption is motivated by our careful reading of the tax history of now developed countries and the literature explaining differences in tax structures across countries, which we present briefly in this section.

Table 3: Tariff revenues as % of total revenues in developed countries in 1850 and 2000

	1850	2000
US	93.1	0.7
Norway	59	0.3
Sweden	36.2	0.2
Great Britain	32.9	0.5
France	11.7	0.3
Spain	10.6	0.5
Prussia/Germany	9.9	0.4

Data source for 1850: Ardant (1972).

It has been recognized since at least Hinrichs (1966) that a country's choice of tax mix depends on its level of development. Rodrik (1995) argues that countries at an early stage of development use mostly taxes on international trade as 'revenue-hungry rulers in countries with poor administrative capabilities know that trade is an excellent tax handle'. In his in-depth history of taxation Ardant (1972) shows that all states initially rely on the taxation of key trading points to provide revenues because transactions in ports and trading cities are the easiest ones to monitor. This idea is reflected in differences in trade tax collection between countries at different stages of development: Riezman and Slemrod (1987) present evidence from the 1970s that countries that rely on tariff revenues for a large share of their revenues do so because the high administrative costs of domestic taxation make tariffs the first best option.

Table 3 shows that in 1850 trade taxes were a large share of total tax revenues in now developed countries. The United States in particular stands out for relying nearly entirely on tariffs for revenues. Great Britain, the richest country at the time, still obtained a third of its revenues from custom duties. In 2000 however tariff revenues represent less than 1% of the total budget in all OECD countries. What happens in between is the 'tax transition' described in

Hinrichs (1966): governments grow over time and they simultaneously decrease their taxes on trade and increase taxation of domestic income and consumption. Figure 4 depicts this evolution in the United States. Until the beginning of the Civil War in 1861 virtually all public revenues came from tariffs. Revenues from trade taxes have since been falling steadily whilst total tax revenues quadrupled as a share of GDP. Most of the increase occurred during two historical events: the entry of the United States into World War One in 1917 and Roosevelt's New Deal starting in 1932. Table presents descriptive statistics on the historical evolution of tax revenues for 9 now-developed countries between 1820 and 1995. Over the period we observe a clear decrease in trade tax revenues and an increase in domestic tax revenues which more than compensates the decrease in revenues from trade taxes.

Table 4: Tax revenues over time in now developped countries

Period	Nb Obs	Trade Tax Revenue	Domestic Tax Revenue	Total Tax Revenue
1820-1849	51	1.39	3.80	5.12
		(0.68)	(4.25)	(3.87)
1850-1899	301	1.84	5.48	7.32
		(0.81)	(4.44)	(4.10)
1900-1949	412	1.66	11.26	12.92
		(1.18)	(9.95)	(9.64)
1950-1995	376	0.64	21.12	21.76
		(0.54)	(6.39)	(6.21)

Standard errors in parentheses. For the period 1820-1849, the sample includes France and the United States; for the rest of the period (1850-1995), Canada, Denmark, Finland, France, Germany, Italy, Japan, Norway and the United States. The data is from Mitchell (2007).

The theoretical framework presented in the following section argues that the simultaneous decline in trade tax revenues and increase in domestic tax revenues was no coincidence. The costly and progressive development of a modern tax administration made domestic taxation on a large scale possible and allowed governments to decrease tariffs, no longer needed as a source of revenue. There are several historical examples of investments in tax capacity which led to a fall in tariffs.

We describe in the introduction how the reintroduction of the income tax in the United Kingdom in 1842 raised enough revenue to allow for the repeal of the Corn Laws. The sharp fall in US tariff rates at the start of the First World War similarly followed the creation of the income tax system (after a temporary existence during the Civil War). The latter was explicitly designed to finance the fall in trade taxes. In 1913 president Woodrow Wilson made a call for revenue reform in his inaugural address with particular emphasis on lower import duties. Shortly afterwards a bill was passed that lowered tariffs from an average of 40% to 29% and included the creation of a federal income tax to compensate for the lost revenues. This change, like the creation of the income tax in the UK, required a large investment in the administrative capacity of the Bureau of Internal Revenue which did not immediately lead to an increase in tax revenues. During the first year of existence of the federal income tax no taxes were paid as taxpayers were only required to return their tax files, giving

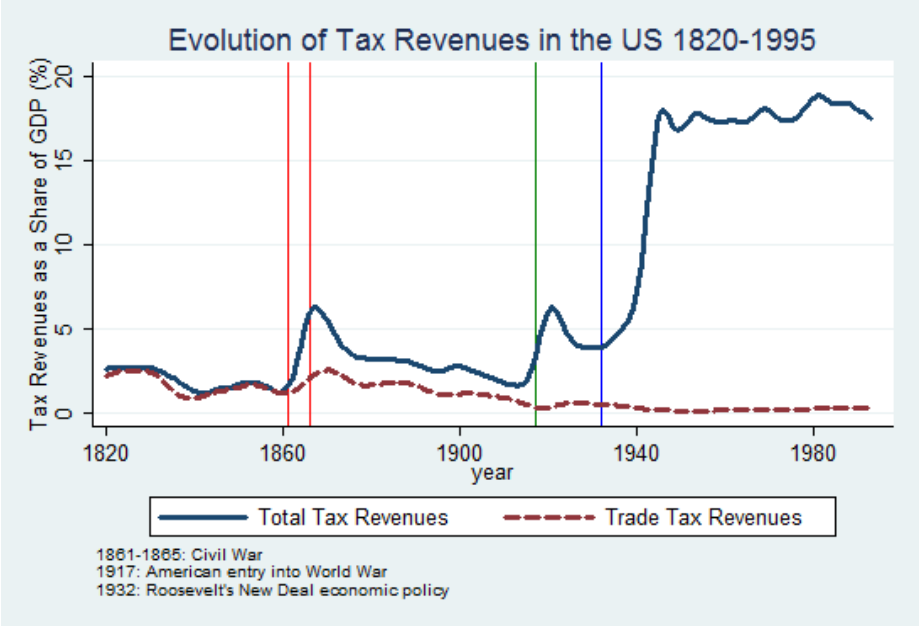


Figure 4: United States

citizens and tax authorities the time to adjust to a new system. The bureau's staff doubled every year from 1917 to 1922 and still lagged behind its charges: when returns for 1918 arrived, the tax files for 1916 had not yet been audited (Witte, 1985).

More generally scholars of tax administrations have long pointed out that raising taxes on domestic income requires the development of large inventories and registers to determine a tax base. This often involves the participation of sophisticated techniques and highly skilled individuals. Ardant (1972) reports for example that in 1830 France the six most famous engineers of the time were asked to create new geometric instruments to help build a registry of property income. This historical evidence motivates our choice to model increases in tax capacity as requiring an investment: resources must be set aside to improve the tax administration, improvements in tax revenues take time to materialize.

The historical experience of now-developed countries teaches us two things. First, tariffs are an easy tax to levy relative to domestic forms of taxation. Second, achieving high levels (by international and historical standards) of domestic taxation is only possible when states have invested sufficiently in the creation of a modern tax administration. The latter idea is at the core of Besley and Persson (2009) who argue that fiscal capacity is a stock that governments decide to invest in. Our model adapts their framework by introducing the first lesson from historical experience – tariffs are easier to levy than domestic taxes – in a model of investment in tax capacity and trade.

4 A model of trade and tax capacity

In this section we develop a simple general-equilibrium model of trade with quasi-linear preferences in which a government decides on fiscal policy subject to a tax capacity constraint. Our baseline model assumes that the government is benevolent. We consider the case of a budget-maximizing government as an extension.

4.1 Set-up

Production

Consider a small open economy which produces and trades three goods A, B and C a numeraire good. We assume that good A is its natural export while B is its natural import. More precisely, we assume that trade policy cannot revert natural comparative advantage patterns. For simplicity, only imports are taxed. Let p_i^W denote the world price of good $i = A, B, C$. The domestic price of good B is $p_B = p_B^W + t$ where t is the trade tax. The price of C is normalized to 1. We write $m(p_B)$ the demand for imports of good B.

The numeraire good C is produced using labor one for one, pinning down the wage rate to 1. Goods A and B are produced combining labor and sector-specific capital according to a constant returns to scale technology. Let Π_i^j be the aggregate rent accruing to sector i. Perfect competition in each sector ensures that:

$$\frac{\partial \Pi_i}{\partial p_i} = y_i \tag{1}$$

where y_i is the production of good i.

Consumption

The country is populated by a continuum of measure one of individuals with identical quasi-linear preferences:

$$U(c, G) = c_C + u_A(c_A) + u_B(c_B) + V(G), \tag{2}$$

where $u_i(\cdot)$ is increasing and concave and c_i denotes consumption of good i. In addition consumers receive utility $V(G)$ from the public good G provided by the government, with $V(\cdot)$ increasing and where we assume that the second derivative V_{GG} is negative and constant for simplicity. All individuals inelastically supply one unit of labor and capital is evenly distributed amongst workers. Aggregate income Y is therefore:

$$Y(p_A^W, p_B^W, t) = 1 + \Pi_A(p_A^W) + \Pi_B(p_B^W + t). \tag{3}$$

The representative consumer maximizes her utility under the following budget constraint:

$$c_0 + p_A^W c_A + (p_B^W + t)c_B \leq Y(p_A^W, p_B^W, t) - T \tag{4}$$

where T is the income tax.[7]

Consumer behavior satisfies the optimality condition:

$$u_i'(c_i) = p_i, \forall i = A, B$$

A convenient property of the quasilinear representation of preferences is that aggregate welfare in the country can be written as:

$$W(p, t, T, G) = Y(p_A^W, p_B^W, t) - T + S_A(p_A^W) + S_B(p_B^W + t) + V(G) \quad (5)$$

where $S_i(p_i)$ denotes the consumer surplus from consumption of good i.

Government

Each country has a government that produces a public good G out of taxes on imports t and a tax on income T. The government is benevolent, discounts future periods at rate β and chooses the trade tax rate freely in each period. We define $R(t) = tm(p_B^W + t)$ the tax revenue collected from trade tax t, with $R_t > 0$ and $R_{tt} < 0$.[8] The level of the income tax T is restricted by the total amount of tax capacity ($\bar{T}$) in the country: $T \leq \bar{T}$.

The government can choose to increase $\bar{T}$ in the future by investing I today from its tax revenues: at time s tax capacity is $\bar{T}_s = \bar{T}_{s-1} + f(I_{s-1})$. The tax technology function $f(\cdot)$ captures the returns to fiscal investment, with $f_I > 0$ and $f_{II} < 0$. A higher f_I means it is easier for the government to increase tax capacity from a given level of investment. The government's budget constraint is therefore $G + I = T + R(t)$.

The government maximizes the indirect utility of the consumers (we drop the terms which are a function of the price of the exported good, which are irrelevant in the government's maximization program):

$$\max_{t_s, T_s, I_s} \sum_{s=0}^{\infty} \beta^s W(p, t_s, T_s, I_s) \quad (6)$$

subject to the constraints:

$$\begin{cases} T_s \leq \bar{T}_s \\ \bar{T}_{s+1} = \bar{T}_s + f(I_s) \\ I_s \geq 0 \\ T_s + t_s m_s - I_s \geq 0 \end{cases}.$$

Combining the first two constraints and assuming that public good provision is always strictly positive this can be rewritten as:

$$\begin{cases} T_s \leq \bar{T}_0 + \sum_{j=0}^{s-1} f(I_j) \\ I_s \geq 0 \\ T_s + t_s m_s - I_s > 0 \end{cases}.$$

[7] Writing T as total tax collection rather than considering the domestic tax *rate* simplifies the results by ruling out interactions between the tax bases of the income tax and the tariff but leaves the model's results unaffected.

[8] We assume that the import function $m(p)$ is not 'too' convex such that $tm_{pp} + m_p < 0$ to ensure that the second order conditions are respected.

4.2 Equilibrium

Solving the government's program we obtain three types of equilibria: a 'full tax capacity equilibrium', in which the government's tax capacity is unconstrained, a 'low tax capacity trap' in which the government remains constrained over time and does not invest, and an 'investment equilibrium' in which the government is initially constrained but gradually increases its tax capacity.

The **full tax capacity equilibrium** occurs when the existing tax capacity $\bar{T}_s$ is enough to satisfy the Samuelson condition for efficient provision of the public good. Countries in this equilibrium have enough tax capacity to equalize the marginal value of the private good (equal to 1) and that of the public good. This case is therefore characterized by a $\bar{T}_s$ such that $V_G(\bar{T}_s) \leq 1$. The government can provide an optimal level of public good by using the domestic tax so it levies no trade tax. T_s^* is such that $V_G(T_s^*) = 1$ and the government does not invest in tax capacity ($I_s^* = 0$).

When the existing level of tax capacity does not suffice to provide an optimal level of public good ($V_G(\bar{T}_s) > 1$) the government levies a trade tax following:

$$\frac{t_s^*}{p_B^W + t_s^*} = \frac{V_{Gs}(G_s) - 1}{V_{Gs}(G_s)}(1/\epsilon) > 0 \tag{7}$$

where ϵ is the (absolute value of) the price elasticity of imports. This equation resembles the well-known inverse elasticity rule for the optimal tariff rate.

The government decides to invest in tax capacity if the marginal cost of investment (forgone public good today) is lower than its marginal return (more public good in future periods), i.e. if:

$$V_{Gs}(G_s) < \sum_{j=1}^{\infty} \beta^j f_I(0)(V_{Gs}(G_s) - 1) \Leftrightarrow \frac{V_{Gs}(G_s)}{V_{Gs(G_s)} - 1} < f_I(0)\frac{\beta}{1-\beta} \tag{8}$$

This condition will never be satisfied for countries in which:

$$f_I(0)\frac{\beta}{1-\beta} \leq 1 \tag{9}$$

Despite their low level of public good provision these countries will remain in a **low tax capacity trap** as the returns to investment are too small for them to ever choose to invest in tax capacity. Intuitively the quantity of public good forgone today as a result of an investment of 1 unit is higher than the (discounted) sum of increased tax revenues generated by this investment ($f_I(0)\sum_{j=1}^{\infty}\beta^j$). Investment cannot be worthwhile whatever the marginal value of the public good. Countries with worse tax technology (lower f_I) and less forward looking governments (lower β) are more likely to find themselves in this type of equilibria.

Countries for which returns to investment are high enough ($f_I(0)\frac{\beta}{1-\beta} > 1$) will invest in tax capacity as long as (8) is satisfied. These countries are in a **tax capacity investment equilibrium**. The optimal level of investment (I^*) is set by:

$$V_G(\bar{T}_s + R(t_s^*) - I_s^*) = \sum_{j=1}^{\infty} \beta^j f_I(I_s^*)(V_G(\bar{T}_s + f(I_s^*) + R(t_{s+j}^*)) - 1). \tag{10}$$

Better tax technology, higher demand for the public good and lower preference for the present lead to more investment as they increase returns. Countries stop investing when their existing level of tax capacity $\bar{T}^{max}$ allows them to reach a level of public good such that:

$$\frac{V_G(\bar{T}^{max} + R(t_s^*))}{V_G(\bar{T}^{max} + R(t_s^*)) - 1} = f_I(0)\frac{\beta}{1-\beta}. \tag{11}$$

Note that this level of tax capacity does not allow countries to reach the full tax capacity equilibrium where $V_G = 1$. When $\bar{T} = \bar{T}^{max}$ the marginal benefit of investing in tax capacity is no longer higher than the marginal cost so investment stops. The presence of an intertemporal cost to raising tax capacity implies that the Samuelson condition for provision of the public good ($V_G = 1$) will not be reached. Countries in an investment equilibrium will therefore continue to use the tax on imports as a source of revenues when they stop investing in tax capacity. We define this level of trade tax as t^{min}, defined by:

$$\frac{t^{min}}{p_B^W + t^{min}} = \frac{V_G(\bar{T}^{max} + R(t^{min})) - 1}{V_G(\bar{T}^{max} + R(t^{min}))}(1/\epsilon) > 0 \tag{12}$$

4.3 Implications

The model predicts the key stylized facts outlined in the previous section regarding the historical evolution of tax revenues in developing countries. First, countries experience a tax transition over time: they increase tax revenues from domestic sources and decrease tariffs (Hinrichs, 1966). This is clearly the evolution experienced by countries in a tax capacity investment equilibrium. They invest in tax capacity, domestic taxation increases and tariffs are lowered.

Second, the so-called 'Wagner's law' states that government size increases over time. This is also a clear prediction of the model for countries in a tax capacity investment equilibrium: as the share of tax revenues coming from domestic taxes increases so does the overall efficiency of the tax system, allowing for higher tax-to-GDP ratios. Rich OECD countries in which the level of taxation has stabilized over the last decades are likely to be in a full tax capacity equilibrium where the share of GDP extracted by the government has reached a long-run steady state level.

Our model can also accommodate the 'ratchet effect theory' (Peacock and Wiseman, 1961) whereby temporary shocks to the demand for the public good such as wars raise government expenditures permanently. To explain why expenditures do not fall back to their pre-shock level once the shock subsides this theory argues that social norms regarding the optimal level of public goods are permanently affected by the temporary shock. Our model offers an alternative explanation. A temporary jump in the marginal value of the public good (V_G) will make a country increase its tax capacity. This tax capacity will remain in place once V_G returns to its equilibrium value, leaving the country with permanently higher domestic taxes and lower tariffs. This is exactly what we observe in the evolution of tax revenues in the United States (Figure 4). Note that such a temporary jump in V_G can explain how countries shift from an equilibrium in which $\bar{T} = \bar{T}^{max}$ to a full tax capacity equilibrium.

Finally we offer a new explanation for the empirical relationship between trade openness and government size (Alesina and Wacziarg, 1998, Rodrik, 1998). In our model the causality stems from government size to trade liberalization. Investments in tax capacity lead to a bigger government that can afford to lower tariffs and therefore opens up to trade.

4.4 Impact of an exogenous decrease in tariff revenues

In this section we consider the impact of an exogenous decrease in tariff revenues ($R(t)$) on total tax revenues. We assume that in most cases the type of decrease in tariff revenues presented in Section 1 cannot be the unconstrained decision of welfare-maximizing governments: the decrease in tariff revenues is exogenous to domestic determinants of public good provision and taxation levels. It could be the consequence of the government's wish to enter a free trade agreement irrespective of fiscal considerations or of external pressure from international institutions or large trade partners. Antrás and Padró i Miquel (2011) argue for example that powerful governments often attempt to change the tariff policies of their trade partners. Going back to the example we use in Section 2.2, a potential explanation for the change in trade policy in Guatemala in 1979 is that it requested an IMF Financial arrangement (a conditional Stand-By Arrangement was approved in November 1981) and that it had to lower its tariffs to meet the IMF's conditions[9]. Whether this fall will be compensated by an increase in domestic tax revenues depends on the type of equilibria the country is facing.

Proposition 1 *Consider an exogenous fall in tariff revenues of dR. (i) Countries in a low tax capacity trap will not recover any of the lost revenue through increased domestic taxation. (ii) Countries in an investment equilibria will invest more and recover at least part of the lost revenue. They will recover more when they have better tax technology and when their government is more forward looking.*[10]

Consider first the case of a country in a low tax capacity trap. Its decision not to invest is set by the condition $f_I(0)\frac{\beta}{1-\beta} \leq 1$ which is not affected by the decrease in tariff revenues. Its level of domestic taxation remains the same, so none of the lost revenue is recovered.

Countries which are in an investment equilibrium will on the contrary increase their level of investment when faced with a decrease in tariff revenues. Using equation (10) we find:

$$dI_s = dR\frac{V_{GG}(1 - f_I(I_s)\beta/(1-\beta))}{V_{GG}(1+\beta/(1-\beta)f_I^2(I_s)) + \sum_{j=1}^{\infty}\beta^j f_{II}(I_s)(V_{G_{s+j}} - 1)} > 0 \text{ if } dR < 0 \tag{13}$$

Intuitively the decrease in tariff revenues hastens the tax transition by improving the government's incentives to invest because it lowers future tax revenues,

[9] Information on the conditions attached to obtaining a loan from the IMF are not publicly available.

[10] Countries in a full tax capacity equilibrium cannot by definition experience such a fall since for them $R(t) = 0$.

making higher tax capacity tomorrow attractive. Similarly countries which had stopped investing before the fall in $R(t)$ will be made to invest again to compensate for the lost revenue. Rewriting (11) it is easy to show that for those countries $d\bar{T}^{max} = -dR$: the maximum level of tax capacity that countries will reach increases.[11]

An exogenous decrease in tariff revenues thus hastens and furthers the tax transition of countries in an investment equilibrium. This comes at a cost however. Whilst tariff revenues fall by dR_t domestic revenues increase by $f_I(dI_t+I_t^*)$ in the first period after the shock, where I_t^* is the level of investment that would have occurred without the shock. The increase in the equilibrium level of investment due to the shock dI_t is not enough to compensate for the fall in tariff revenues. Rewriting equation (13) we find that:

$$f_I dI < -dR. \tag{14}$$

Intuitively the government seeks to spread the welfare cost of lower tariff revenues over the current and future periods, complete revenue recovery in the short-run is not guaranteed. The extent of revenue recovery will depend on the size of $f_I(dI_t+I_t^*)$ compared to dR_t: the country is more likely to recover the lost revenue the higher the tax technology (f_I) and the initial level of investment. Over time, as tax investments accumulate, the country becomes increasingly more likely to recover the lost tariff revenues. In the long-run all countries in an intermediate equilibrium recover. When the shock leads a to a new level of trade tax such that $t < t^{min}$ (equation (12)) the long run tax mix is more efficient (because more skewed towards domestic taxation) and allows for a higher overall level of taxation. As we show below the same long-run equilibrium can be obtained without the short-run welfare loss by raising tax capacity prior to lowering trade taxes.

4.5 Increasing tax capacity leads to more trade openness

Consider now what happens if the country is given an amount X of public revenues to invest in tax capacity, for example through technical aid to improve its tax administration. This will lead to an increase in domestic taxes of $f(X)$ in countries which are in a low tax capacity trap. The increase will be smaller but positive in countries which are in a tax capacity investment equilibrium as they will lower the amount of investment in tax capacity that they themselves finance. Formally:

$$dI^* = -X\frac{f_I(I_s)V_{GG}(f_I\beta/(1-\beta)-1)}{\sum_{j=1}^{\infty}\beta^j f_{II}(I_s)(V_G(G_{s+j})-1)+V_{GG}(\beta/(1-\beta)-1)f_I^2+1} \tag{15}$$

where $0 > dI^*$ and $-dI^* < X$ so that tax capacity in the country increases.

In both cases the country will now endogenously lower its tax on imports as it has access to more capacity to levy domestic taxes:

$$dt^* = \frac{-V_{GG}f_I(I_s)R_t(X-dI^*)}{m_p(V_G-1)+V_G(G_s)(tm_{pp}+m_p)+V_{GG}R_t^2} < 0 \tag{16}$$

[11] This holds for any country for which the fall in $R(t)$ leads to a level of trade tax that is below that in equation (12) at which the country stops investing.

where $dI^* = 0$ for countries in a low tax capacity trap. Providing countries with funds to invest in tax capacity will yield a double dividend: more tax revenues, and a less distortive tax system. Note that this is true even in countries in low capacity traps in which the government itself may not find it optimal to invest in tax capacity. Our model does not include gains from trade liberalization beyond the increase in consumer surplus, but it suggests that such potential gains (higher growth, or positive externalities on trade partners) can be reached through investments in tax capacity.

4.6 Extension: budget-maximizing government

We now consider what happens if the government maximizes its intertemporal budget $\sum_{s=0}^{\infty} \beta^s (T_s + t_s m_s - I_s)$ instead of welfare[12].

The government's budget maximization is subject to the constraints:

$$\begin{cases} T_s \leq \bar{T_0} + \sum_{j=0}^{s-1} f(I_j) \\ I_s \geq 0 \\ T_s + t_s m_s - I_s > 0 \end{cases} .$$

This government places no weight on the welfare cost of using the trade tax. It will always choose the trade tax rate that maximizes trade tax revenues:

$$\frac{t_s^*}{p_B^W + t_s^*} = -1/\epsilon > 0 \tag{17}$$

It also sets $T^* = \bar{T_s}$ in all periods since not doing so leads to forgone revenues. There is therefore no 'high tax capacity equilibria' in which trade taxes are not used and the existing tax capacity is sufficient for the government to meet its objective. Neither does this version of the model predict that countries will choose to decrease trade taxes over time as they increase domestic tax.

The government invests in tax capacity if the marginal cost of investment (forgone revenues today) is lower than its marginal returns (more revenues in future periods), i.e. if:

$$f_I(0) \frac{\beta}{1-\beta} \geq 1 \tag{18}$$

A country in which condition (18) is not satisfied is thus in a **low tax capacity trap** regardless of whether its government maximizes welfare or its own budget.

When $f_I(0) \frac{\beta}{1-\beta} \geq 1$ the government will invest an amount I^* such that:

$$f_I\left(I^*\right) \frac{\beta}{1-\beta} = 1 \tag{19}$$

[12]This is an extreme case of a non-benevolent government. One could think instead of an intermediate case in which the government maximizes a weighted sum of the representative citizen's welfare and a share of the budget captured as a rent. As we will show however predictions of the model are very similar in the polar cases of benevolent and budget-maximizing governments – the recovery from an exogenous fall in tariff revenues is similar in both cases – though normative implications differ. Since what we are interested in here are the predictions regarding revenue recovery we focus on this simpler framework.

This optimal investment level does not depend on the existing level of tax capacity or the trade tax: the government will always invest the same (intertemporal) revenue-maximizing amount in tax capacity. All countries in which $f_I(0)\frac{\beta}{1-\beta} \geq 1$ are therefore in an investment equilibrium.

Budget-maximizing governments clearly invest more often in tax capacity than benevolent ones . They also tend to invest higher amounts in tax capacity: comparing (10) and (19) we see that for reasonable values of the marginal value of the public good (less than twice that of private consumption) benevolent governments choose lower equilibrium investment levels than their budget-maximizing counterparts as they do not take into account the (direct) cost of paying taxes.

Assuming that the government maximizes its budget rather than citizens' welfare leaves unchanged the impact of an exogenous decrease in trade tax revenues (Proposition 1). Countries in a low tax capacity trap will, by definition, recover none of the lost trade tax revenues through domestic taxation. Countries in an investment equilibria will recover some, thanks to the positive level of investment in tax capacity. Whether they will recover more or less than countries governed by benevolent governments is ambiguous. On the one hand, benevolent governments increase their investment when confronted to an exogenous decrease in tariff revenues. Budget-maximizing governments do not, as they always choose the revenue-maximizing level of investment. On the other hand, as explained above, a budget-maximizing government likely invests more in tax capacity than a benevolent one regardless of the decrease in trade tax revenues. As in the benevolent government case the speed of recovery will depend on the relative values of tax technology and the government's discount rate (f_I and β).

The testable predictions of the model are therefore unaffected by our assumption regarding the government's objective function. The welfare impact of a decrease in trade tax revenues is however very different. If we think the government is purely rent-taking and produces no public good, the decrease has a clear positive impact on citizens' welfare, increasing consumer surplus at no cost. Finally, note that the prediction that providing the country with funds to invest in tax capacity will lead to lower tariffs does not follow through in this extension of the model.

5 Why did some countries recover? Empirical evidence

5.1 Data and empirical strategy

A first empirical validation of our model is found in Tables 1 and 2 which show that some countries did not immediately recover the lost revenues from trade taxes through increases in domestic taxes. This is in line with the prediction of the model that a country in a tax capacity investment equilibrium will suffer a short-run fall in total tax revenues following an exogenous decrease in trade taxes. The fact that some countries never recover in our sample also suggests that the low tax capacity trap equilibrium is empirically relevant. In this section we test the model's predictions regarding which country characteristics affect

the probability of recovery.

The model predicts that countries with better returns to tax investments (higher f_I) are more likely to increase their domestic taxation after a fall in tariff revenues. There is no straightforward proxy for tax technology. The size of the informal sector is the ideal candidate as it is likely to be harder to increase domestic tax collection in a country where a large share of transactions are unobserved by the state. Information on the informal sector is however rarely available for recent years, let alone since 1945. We consider three variables that are likely correlants with returns to tax investment as they make collecting wide-based domestic taxes easier: the share of agriculture in GDP, population density and capital account openness. Controlling for the level of economic development, the share of agriculture in GDP is likely correlated with the size of the informal sector (Alm and Martinez-Vazquez, 2007). Historical evidence that low population densities make taxing domestic income more of a challenge is found in Irwin (2002) who argues that "in terms of public finance, import taxes made sense for countries with low population densities. Other means of raising revenue (...) were not as feasible or as enforceable in countries with a widely dispersed population." (p. 162) (see also Acemoglu, Johnson, and Robinson (2002)). Finally it has been argued that capital account openness lowers the capacity of countries to levy income taxes, particularly corporate income taxes, because it makes fighting tax avoidance and evasion harder (Devereux, Lockwood, and Redoano, 2003).

Besley and Persson (2009) study how political characteristics of a country affect investments in state capacity. They argue that countries that have inclusive political institutions are more likely to invest in tax capacity because their governments have more interest in increasing future public good provision. We follow them in proxying for political inclusiveness using the democracy variable from the Polity 4 dataset. We also consider their hypothesis that countries facing an external threat are more likely to construct state capacity. In our empirical setting this implies that countries experiencing a war at the time of the start of the episode or in the years following will invest more, and thus are more likely to recover the lost tax revenues. We use data from the Correlates of War database to create indicators of whether the country was in a war (excluding civil wars) at the time of the shock and in the 2 or 10 years following the shock. Both more democratic governments and wars are likely to increase the demand for public good provision. The inclusion of these variables as determinants of recovery is therefore also in line with the model's prediction that countries with a higher marginal value of the public good are likely to recover faster.[13]

Formally, we estimate the following equation:

$$P_{is} = \alpha + X'_{is}\beta + Z'_{is}\delta + \epsilon_{is} \tag{20}$$

where i indexes countries and s years, P_{is} is an indicator equal to 1 if country i experiencing an episode starting in year s recovers the lost tariff revenues after 2 or 10 years. X_{is} is the set of determinants of recovery measured at the start of the episode and Z_{is} is a set of control variables. We allow for the possibility that

[13]The theory also predicts that governments with higher discount rates will recover the lost tax revenues faster. There is however no clear empirical counterpart for this parameter – variables proxying for end of political terms are not available for our whole sample.

economic development directly leads to higher tax to GDP ratios (as predicted for example by Kleven, Kreiner, and Saez (2009)) by including GDP per capita at the time of the shock. High GDP growth could lead to decreases in tax GDP ratios so we also control for average GDP growth between year s and year $s+2$ (when P_{is} is recovery after 2 years) or year $s+10$ (when P_{is} is recovery after 10 years).

Some of the episodes we identify may correspond to decreases in trade tax revenues that are not the consequence of a 'shock' exogenous of fiscal considerations but are part of the process of tax transition described by the model. In these cases recovery is immediate, as the fall in trade taxes is simultaneous to the increase in tax capacity. We expect these episodes to be characterized by smoother decreases in tariff revenues – smaller episode sizes, over longer periods. We therefore control throughout for the length and size of the episodes to help disentangle between the two types of episodes. Revenue recovery should occur faster for longer episodes of smaller size.

We use OLS as our baseline specification to estimate equation (20). Table 5 presents descriptive statistics for the potential determinants of recovery for the sample of episodes using both definitions described above. Strong multicollinearity between the variables is potentially a concern so we consider the impact of each variable on the probability of recovery separately and simultaneously.

Table 5: Descriptive Statistics

	Mean	SD	Nb obs
Density	1.2	4.1	107
Agr\ GDP	24.0	15.6	100
Capital openness	0.9	0.3	103
Democracy	-1.4	6.7	96
War this year or next	0.1	0.2	110
War in next 10 years	0.2	0.4	110
GDP per capita	22.3	30.4	107

See Appendix C for a description of the variables.

5.2 Results

Table 6 considers the determinants of revenue recovery ten years after the start of the episode. All variables have the expected sign. Population density stands out as a key determinant of the probability of revenue recovery suggesting that countries facing a more 'tax friendly' environment find it easier to increase domestic taxes to respond to the revenue shock. Coefficients for the other two proxies for tax technology – share of agriculture in GDP and capital openness – are of the expected sign but not statistically significant when all coefficients are estimated simultaneously. More politically inclusive countries and those at war at some point in the 10 years following the shock are also more likely to recover in line with the predictions in Besley and Persson (2009). Finally, the coefficients for the magnitude and the length of the episodes are of the expected

sign, though not statistically significant: the bigger the episode, the lower the probability of recovery, and the longer the episode, the higher this probability.

The estimation results in Table 7 for the probability of recovery in the short-run (two years) paint a similar picture. Population density and democracy again stand out as important determinants of recovery, but being at war seems to have no impact in the short-run.[14] The characteristics of the episodes (size and length) seem particularly important in determining revenue recovery in the short-run. This is consistent with the idea that including those variables enables us to disentangle the episodes that are the consequence of shocks which are exogenous to fiscal considerations and those which are part of a smooth tax transition, as revenue recovery is immediate for the latter.

Table 6: Determinants of revenue recovery after 10 years

	1	2	3	4	5	6	7
Density	0.013**						0.012**
	(0.005)						(0.005)
Agr\ GDP		-0.006**					-0.002
		(0.003)					(0.004)
Capital openness			-0.052				-0.115
			(0.165)				(0.214)
Democracy				0.019**			0.027***
				(0.008)			(0.009)
War in next 10 years					0.253**		0.300**
					(0.118)		(0.133)
GDP per capita						0.003***	0.001
						(0.001)	(0.003)
Size of the episode (% GDP)	-0.005	-0.000	-0.003	-0.007	-0.011	-0.004	-0.005
	(0.018)	(0.017)	(0.018)	(0.018)	(0.018)	(0.018)	(0.019)
Length of the episode (years)	0.005	0.006	0.005	0.006	0.007	0.004	-0.000
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Observations	107	100	103	96	107	107	88

Robust standard errors in parentheses. All results are obtained using an OLS specification and controlling for GDP growth in the next 2 or 10 years. An observation is an episode, defined using the tax to GDP ratios as explained above. See Appendix C for a description of the variables.

The creation of a Value Added Tax (VAT) system may be an example of an investment in tax capacity. In Table 8 we consider whether having a VAT system at the start of the episode or creating one during the period under consideration affects the probability of recovery. We find no such impact (with or without additional controls). This is in line with the result in Baunsgaard and Keen (2010) that the presence of a VAT does not affect revenue recovery. This may be because the creation of a VAT, often recommended by international financial institutions to countries in a fiscal crisis, is a complex undertaking that was not successful in increasing domestic taxation in the countries in our sample, or was undertaken precisely by the countries which faced the most severe

[14] Only six countries are at war in the two years following the start of the episode.

Table 7: Determinants of revenue recovery after 2 years

	1	2	3	4	5	6	7
Density	0.008*						0.009*
	(0.004)						(0.005)
Agr\ GDP		-0.004					0.000
		(0.003)					(0.004)
Capital openness			-0.179				-0.147
			(0.162)				(0.190)
Democracy				0.013			0.016*
				(0.008)			(0.009)
War this year or next					-0.020		0.056
					(0.229)		(0.251)
GDP per capita						0.002	0.003
						(0.001)	(0.002)
Size of the episode (% GDP)	-0.028*	-0.025	-0.025*	-0.030*	-0.029*	-0.028*	-0.021
	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.015)	(0.016)
Length of the episode (years)	0.020**	0.018*	0.019**	0.018*	0.021**	0.019**	0.009
	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.010)
Observations	107	100	103	96	107	107	88

Robust standard errors in parentheses. All results are obtained using an OLS specification and controlling for GDP growth in the next 2 or 10 years. An observation is an episode, defined using the tax to GDP ratios as explained above. See Appendix C for a description of the variables.

fiscal constraints.

Robustness Checks

As explained above our method could miss-classify countries as having not recovered if they anticipated the shock by increasing domestic taxation before the decrease in tariffs. To deal with this potential concern we restrict the sample to only non-anticipated episodes using the definition described in Section 2: we drop the 7 cases in which we observe an increase in domestic taxes at least as large as the fall in trade taxes during the 5 years preceding the episode. Doing so leaves results unchanged (Table 9).

Episodes which are caused by a national crisis – for example a civil war – are unlikely to be associated with fast revenue recovery irrespective of the country's characteristics. In Table 10 we drop these episodes and only consider those which are associate with trade liberalization, a shock in exchange rates or a fall in trade volumes. We find similar results on this smaller sample though proxies for tax technology are no longer statistically significant determinants of revenue recovery. Controlling for decade fixed effects similarly does not affect the results, though some estimates loose statistical significance due to a lack of power (Table 11). This suggests that a general trend towards better managed tax transitions over time as macro-economic conditions change cannot explain our findings.

The Tables Appendix presents similar robustness checks for the probability

Table 8: VAT as a determinant of revenue recovery after 10 years

	1	2	3	4	5	6
VAT at time s	0.052	0.032				
	(0.126)	(0.132)				
VAT at time $s+10$			0.018	-0.149		
			(0.102)	(0.112)		
VAT created					-0.019	-0.177
					(0.113)	(0.122)
Other determinants	No	Yes	No	Yes	No	Yes
Observations	107	88	107	88	107	88

Robust standard errors in parentheses. All results are obtained using an OLS specification and controlling for GDP growth in the next 2 or 10 years. The variable 'VAT at time s' is equal to 1 if the country has a VAT system at the start of the episode, 0 otherwise. The variable 'VAT at time $s+10$' is equal to 1 if the country has a VAT system 10 years after the start of the episode, 0 otherwise. The variable 'VAT created' is equal to 1 if the country creates a VAT system in the 10 years following the start of the episode, 0 otherwise. An observation is an episode, defined using the tax to GDP ratios as explained above.

Table 9: Determinants of revenue recovery after 10 years, non-anticipated episodes only

	1	2	3	4	5	6	7
Density	0.013**						0.011**
	(0.005)						(0.005)
Agr\ GDP		-0.006*					-0.002
		(0.003)					(0.004)
Capital openness			-0.062				-0.108
			(0.165)				(0.220)
Democracy				0.019**			0.027***
				(0.008)			(0.009)
War in next 10 years					0.247*		0.261*
					(0.125)		(0.139)
GDP per capita						0.003***	0.001
						(0.001)	(0.003)
Size of the episode (% GDP)	-0.002	0.003	-0.001	-0.004	-0.009	-0.002	-0.002
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.019)
Length of the episode (years)	0.005	0.005	0.005	0.005	0.007	0.004	-0.001
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Observations	100	93	97	89	100	100	82

Robust standard errors in parentheses. All results are obtained using an OLS specification and controlling for GDP growth in the next 2 or 10 years. An observation is an episode, defined using the tax to GDP ratios as explained above. See Appendix C for a description of the variables.

of revenue recovery in the short-run which leave our main findings unchanged. We also estimate equation (20) on our sample of episodes of tariff revenue decreases defined using tax data normalized by population as explained above. Our findings are robust to using this alternative definition of episodes though most coefficients are not statistiscally significant when jointly estimated on this sample. Interestingly having a VAT system in place seems to decrease the probability of recovery in this sample, though this could be because countries adopt VAT systems when they are facing severe fiscal constraints. Finally results obtained when one changes the thresholds used to define episodes are in the paper's online Appendix. We consider episodes defined by a 2 GDP points fall in trade taxes or a 30% fall in trade taxes revenue per capita. These more conservatives definitions yield a smaller number of episodes and hence decrease the sample size and power of the estimation but the coefficients' estimated values are very similar in most cases.

Table 10: Determinants of revenue recovery after 10 years, episodes for which the cause is identified only

	1	2	3	4	5	6	7
Density	0.028						0.008
	(0.028)						(0.055)
Agr\ GDP		-0.005					0.000
		(0.004)					(0.005)
Capital openness			0.057				-0.014
			(0.225)				(0.288)
Democracy				0.018*			0.022**
				(0.009)			(0.010)
War in next 10 years					0.396***		0.422***
					(0.111)		(0.133)
GDP per capita						0.003***	0.003
						(0.001)	(0.002)
Size of the episode (% GDP)	0.004	0.004	0.008	0.006	-0.001	0.008	0.004
	(0.019)	(0.019)	(0.019)	(0.018)	(0.019)	(0.019)	(0.020)
Length of the episode (years)	0.004	0.003	0.002	0.003	0.005	0.002	-0.003
	(0.011)	(0.011)	(0.011)	(0.012)	(0.011)	(0.011)	(0.012)
Observations	80	77	77	72	80	80	67

Robust standard errors in parentheses. All results are obtained using an OLS specification and controlling for GDP growth in the next 2 or 10 years. An observation is an episode, defined using the tax to GDP ratios as explained above. See Appendix C for a description of the variables.

Table 11: Determinants of revenue recovery after 10 years with decade fixed effects

	1	2	3	4	5	6	7
Density	0.016***						0.015**
	(0.005)						(0.006)
Agr\ GDP		-0.004					0.000
		(0.004)					(0.004)
Capital openness			-0.102				-0.144
			(0.174)				(0.225)
Democracy				0.013			0.021**
				(0.009)			(0.010)
War in next 10 years					0.226*		0.260*
					(0.120)		(0.156)
GDP per capita						0.003***	0.002
						(0.001)	(0.003)
Size of the episode (% GDP)	-0.001	0.003	0.001	-0.001	-0.008	-0.001	0.002
	(0.019)	(0.019)	(0.019)	(0.019)	(0.020)	(0.019)	(0.021)
Length of the episode (years)	0.008	0.009	0.006	0.006	0.011	0.008	-0.000
	(0.011)	(0.010)	(0.011)	(0.011)	(0.010)	(0.010)	(0.012)
Observations	107	100	103	96	107	107	88

Robust standard errors in parentheses. All results are obtained using an OLS specification and controlling for GDP growth in the next 2 or 10 years. An observation is an episode, defined using the tax to GDP ratios as explained above. See Appendix C for a description of the variables.

6 Conclusion

This paper provides new evidence on the fiscal cost of trade liberalization. Using a novel dataset covering 103 developing countries between 1945 and 2006 we identify 110 episodes of decreases in tariff revenues and show that on average the fall of trade taxes was of nearly 4 GDP points. Only 55% of the countries recover the lost revenue through other tax resources 10 years after the shock. The picture is similar when we consider government expenditures. We find evidence that, as predicted by our model, more inclusive political institutions and a more tax-friendly economic environment lead to a higher probability of revenue recovery.

Our argument is not that trade liberalization is bad *per se*. In the long run a fall in tariffs will in our model have a positive impact on welfare as it increases the efficiency of the tax system. However the model points out that the net effect will be always negative for countries which are trapped in a low tax capacity equilibrium. We indeed observe that nearly a third of countries which experience a fall in trade tax revenues never recover the lost revenues through other means. Other countries will suffer from a short-run loss, but will be better off in the long-run. Our model finally suggests that the gains from trade liberalization can be obtained by investing in tax capacity. Building more efficient tax administrations in developing countries may lead them to open up to trade as they will no longer need to levy tariffs to raise revenue, though other protectionist motives for raising tariffs may be at play.

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A Countries in our sample

Countries followed by * are included in the descriptive statistics presented in the introduction but excluded from the remainder of the analysis because they levy less than 1% of GDP in trade taxes at the start of the period.

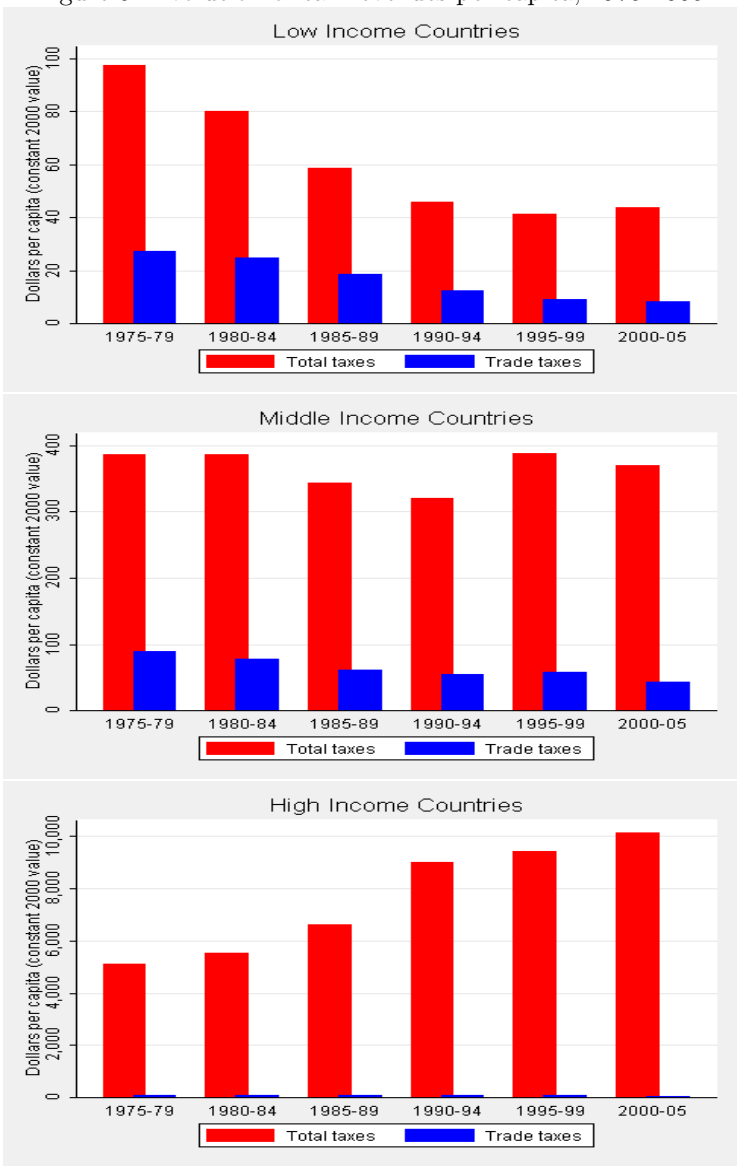
High Income Countries: Australia*; Austria*; Bahamas; Belgium*; Canada*; Denmark *; Finland*; France*; Germany*; Greece; Iceland; Ireland *; Italy *; Japan *; Korea; Kuwait; Luxembourg*; Netherlands*; New Zealand*; Norway*; Portugal; Singapore; Slovenia; Spain *; Sweden *; Switzerland *; United Arab Emirates *; United Kingdom*; United States*.

Middle Income Countries: Algeria; Argentina; Belize; Bolivia; Botswana; Brazil*; Bulgaria; Chile; China; Colombia; Costa Rica; Djibouti; Dominica; Dominican Republic; Ecuador; Egypt; El Salvador; Equatorial Guinea; Fiji; Gabon; Guatemala; Guyana; Honduras; Jamaica; Jordan; Malaysia; Mauritania; Mauritius; Mexico; Morocco; Namibia; Nicaragua; Oman*; Panama; Paraguay; Peru; Philippines; South Africa; Sri Lanka; Suriname; Swaziland; Syria; Thailand; Trinidad and Tobago; Tunisia; Uruguay; Vanuatu; Venezuela.

Low Income Countries: Bangladesh; Benin; Bhutan *; Burkina Faso; Burundi; Cameroon; Central African Republic; Chad; Comoros; Congo, Rep; Cte d'Ivoire; Ethiopia; Gambia; Ghana; Guinea; Haiti; India; Indonesia; Kenya; Lesotho; Madagascar; Malawi; Mali; Mozambique; Myanmar; Nepal; Niger; Nigeria; Pakistan; Papua New Guinea; Sao Tome and Principe; Senegal; Sierra Leone; Tanzania; Togo; Uganda; Zambia; Zimbabwe.

B Evolution of tax revenues 1975-2005, alternative definition

Figure 5: Evolution of tax revenues per capita, 1975-2005



All values are median values for the country group and time period considered. The sample includes in each time period 26 low income countries, 40 middle income countries and 32 high income countries. See Appendix A for the list of countries included in our sample and Appendix C for a description of the variables.

C Data Sources

C.1 Tax and Public Expenditure Data

We collect tax data (total taxes and trade taxes) from three different data sources: data from Baunsgaard and Keen (2010), *Historical Government Finance Statistics* and recent *Government Finance Statistics* data; and Mitchell (2007).

Baunsgaard and Keen (2010) take the Government Finance Statistics (GFS) produced by the IMF as their starting point and complement it using the revenue information provided in the context of the IMF's periodic consultations with member countries ('Article IV' data). They obtained an unbalanced panel of 117 countries for the period 1975–2006.

We merge Historical GFS data for the period 1972-1989 with more recent GFS data (1990-2006). We follow the instructions in *Government Finance Statistics Manual 2001 Companion Material – Classification of GFSM 1986 Data to the GFSM 2001 Framework* (IMF, 2001).

We use data for the central government budgetary sector rather than the general government budgetary sector, because coverage is much better for central government data.

The data are in cash since for Historical GFS we do not have accrual data. With the cash basis, flows are recorded when cash is received or disbursed.

Since all the GFS data are in local currency units, we check the currency used (which is not always the same for Historical and current GFS data) and correct a number of mistakes as to the units. We then convert all the data in USD$ and correct a couple of inconsistencies.

We digitize data from Mitchell (2007) for the developing countries for which data is available for the period 1945-2000: Mexico; Argentina; Brazil; Chile; Colombia; Peru; Uruguay; Venezuela; South Africa; India; Indonesia; Iran; Japan; South Korea; Pakistan; Phillippines; Thailand; Turkey; Australia; and New Zealand. We check consistency between this dataset and the GFS or Baunsgaard and Keen (2010) datasets for the periods for which data is available for more than one source.

We similarly combine GFS, HGFS data and data from Mitchell (2007) to obtain data on government expenditures.The data used to scale tax revenues by GDP or population size comes from the WDI and Maddison (2008).

C.2 Covariates

Agricultural share of GDP (%): World Development Indicators (WDI).

Capital Account Openness: IMF *Annual Report on Exchange Arrangements and Exchange Restrictions*, available from 1950[15].

Democracy: Polity2 index of the Polity IV project.

[15]We thank Michael Klein for providing us with this data.

Exchange rate: WDI.

GDP (constant US dollars): WDI.

Population: World Economic Outlook (WEO) and WDI.

Population density: WDI.

Tariff: Clemens and Williamson (2004) for 1945-1999; WDI for 2000-2006.

VAT: VAT variable (date at which each country established a VAT) created by using three different data sources: (i) for African countries only, Krever (2008); (ii) Purohit (1993); and (iii) Ebrill (2001).

War: War variables are created using data from the Correlates of War database.'War in the next ten (two) years' is an indicator equal to one if the country is coded as being at war with an external enemy in the *Correlates of War* database in the ten (two) years following the start of the episode.

D List of episodes and causes

The source of the shock is marked 'FTA' if the country enters a free trade agreement just before or after the shock, 'Fall tariffs (trade)' if we see a clear fall in the tariffs (trade) data and 'exchange rates' if there is a clear break in the exchange rate data. All other source types are self-explanatory.

Country	Date of shock	Source of shock
Algeria	1995	FTA
Bahamas	1984	FTA
Bahamas	1994	Fall tariffs
Bangladesh	1978	Fall tariffs
Belize	1988	Fall trade
Benin	1979	Fall trade
Botswana	1981	.
Botswana	1992	FTA
Bulgaria	1993	FTA
Burkina Faso	1977	Fall tariffs
Burundi	1978	Fall trade
Burundi	1987	Fall tariffs
Cameroon	1976	Liberalization reforms (since 1972)
Central African Republic	1979	Exchange rates
Chad	1999	FTA
Chile	1985	Fall trade
China	1985	Liberalization reforms
Colombia	1987	Fall tariffs
Comoros	1983	Fall trade
Congo, Rep.	1975	Fall trade
Congo, Rep.	1992	FTA
Costa Rica	1983	.
Côte d'Ivoire	1979	Fall tariffs
Djibouti	1984	.
Dominica	1989	FTA
Dominican Republic	1975	.
Dominican Republic	1999	Fall tariffs
Ecuador	1979	FTA
Egypt	1979	Exchange rates
Egypt	1993	FTA
El Salvador	1978	Fall trade
El Salvador	1985	Earthquake
Equatorial Guinea	1985	Joins CFA zone
Ethiopia	1978	War
Fiji	1990	FTA
Gabon	1985	.
Gambia	1985	Fall tariffs
Ghana	1978	Fall tariffs
Greece	1980	FTA
Guatemala	1977	Fall tariffs
Guinea	1978	.
Guyana	1975	FTA
Guyana	1993	FTA
Haiti	1980	.
Honduras	1991	FTA
Iceland	1975	Fall trade
India	1987	Fall tariffs
Indonesia	1951	FTA
Indonesia	1970	Exchange rates
Jordan	1978	Fall tariffs
Jordan	1993	FTA
Kenya	1980	.
Kenya	1995	FTA
Korea	1979	Fall trade
Lesotho	1983	FTA
Lesotho	1994	FTA
Madagascar	1978	Fall trade
Madagascar	1987	Fall tariffs
Malawi	1995	FTA
Malaysia	1979	.
Mali	1975	Fall trade

Country	Date of shock	Source of shock
Malta	1990	FTA
Mauritania	1984	Fall trade
Mauritius	1987	Fall tariffs
Mexico	1981	FTA
Morocco	1993	FTA
Mozambique	1980	Political unrest (civil war)
Mozambique	1989	FTA
Myanmar	1981	.
Namibia	1985	Political unrest (interim admin. of SAfrica)
Namibia	1991	FTA
Nicaragua	1990	FTA
Niger	1980	Fall trade
Pakistan	1950	FTA
Pakistan	1988	Fall tariffs
Panama	1975	.
Papua New Guinea	1995	FTA
Paraguay	1978	Fall tariffs
Peru	1952	FTA
Peru	1979	.
Philippines	1974	FTA
Philippines	1993	FTA
Portugal	1975	Fall tariffs
Sao Tome and Principe	1981	.
Senegal	1979	Fall tariffs
Senegal	1991	FTA
Sierra Leone	1978	Political unrest
Sierra Leone	1986	Exchange rates
Singapore	1977	.
Slovenia	1994	FTA
South Africa	1969	Fall tariffs
Sri Lanka	1979	Fall tariffs
Suriname	1980	FTA
Swaziland	1979	Exchange rates
Syria	1975	.
Tanzania	1980	Fall tariffs
Tanzania	1994	FTA
Thailand	1964	Fall tariffs
Thailand	1990	FTA
Togo	1978	.
Trinidad and Tobago	1980	Fall trade
Tunisia	1983	Fall tariffs
Tunisia	1991	FTA
Uganda	1984	Exchange rates
Uruguay	1990	FTA
Vanuatu	1987	.
Venezuela	1958	Change political regime
Zambia	1972	Fall tariffs
Zambia	1991	FTA
Zimbabwe	1992	FTA

E Table Appendix

E.1 Robustness checks on revenue recovery after two years

Table E.1: Determinants of revenue recovery for non-anticipated episodes

	1	2	3	4	5	6	7
Density	0.008*						0.010*
	(0.004)						(0.005)
Agr\ GDP		-0.003					0.000
		(0.003)					(0.004)
Capital openness			-0.195				-0.155
			(0.160)				(0.192)
Democracy				0.011			0.015
				(0.008)			(0.009)
War this year or next					-0.133		-0.088
					(0.250)		(0.260)
GDP per capita						0.002	0.003
						(0.002)	(0.003)
Size of the episode (% GDP)	-0.024	-0.021	-0.022	-0.026*	-0.025	-0.024	-0.017
	(0.015)	(0.016)	(0.015)	(0.015)	(0.015)	(0.015)	(0.016)
Length of the episode (years)	0.019**	0.017*	0.019**	0.017*	0.020**	0.019**	0.007
	(0.010)	(0.009)	(0.009)	(0.010)	(0.009)	(0.009)	(0.011)
Observations	100	93	97	89	100	100	82

Robust standard errors in parentheses. All results are obtained using an OLS specification and controlling for GDP growth in the next 2 or 10 years. An observation is an episode, defined using the tax to GDP ratios as explained above. See Appendix C for a description of the variables.

Table E.2: Determinants of revenue recovery when the cause of the episode is identified

	1	2	3	4	5	6	7
Density	0.002						0.034
	(0.030)						(0.065)
Agr\ GDP		-0.003					0.001
		(0.004)					(0.005)
Capital openness			-0.127				-0.093
			(0.221)				(0.256)
Democracy				0.012			0.009
				(0.009)			(0.011)
War this year or next					-0.087		-0.053
					(0.307)		(0.304)
GDP per capita						0.002	0.004**
						(0.002)	(0.002)
Size of the episode (% GDP)	-0.023	-0.025	-0.018	-0.019	-0.023	-0.022	-0.013
	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)	(0.018)
Length of the episode (years)	0.020*	0.017	0.019*	0.016	0.020*	0.019*	0.009
	(0.010)	(0.011)	(0.011)	(0.011)	(0.010)	(0.010)	(0.012)
Observations	80	77	77	72	80	80	67

Robust standard errors in parentheses. All results are obtained using an OLS specification and controlling for GDP growth in the next 2 or 10 years. An observation is an episode, defined using the tax to GDP ratios as explained above. See Appendix C for a description of the variables.

Table E.3: Determinants of revenue recovery with decade fixed effects

	1	2	3	4	5	6	7
Density	0.010*						0.012**
	(0.005)						(0.006)
Agr\ GDP		-0.003					0.001
		(0.003)					(0.004)
Capital openness			-0.205				-0.190
			(0.167)				(0.209)
Democracy				0.011			0.012
				(0.009)			(0.010)
War this year or next					-0.017		0.063
					(0.249)		(0.247)
GDP per capita						0.002	0.003
						(0.001)	(0.003)
Size of the episode (% GDP)	-0.026*	-0.023	-0.023	-0.027*	-0.027*	-0.026	-0.016
	(0.015)	(0.016)	(0.015)	(0.016)	(0.015)	(0.015)	(0.016)
Length of the episode (years)	0.019*	0.017*	0.018*	0.016	0.021**	0.019*	0.005
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.011)
Observations	107	100	103	96	107	107	88

Robust standard errors in parentheses. All results are obtained using an OLS specification and controlling for GDP growth in the next 2 or 10 years. An observation is an episode, defined using the tax to GDP ratios as explained above. See Appendix C for a description of the variables.

E.2 Main results using the 'per capita' definition of episodes

Table E.4: Determinants of revenue recovery after 10 years

	1	2	3	4	5	6	7
Density	0.007**						-0.002
	(0.003)						(0.005)
Agr\ GDP		-0.005**					-0.001
		(0.003)					(0.003)
Capital openness			-0.059				-0.058
			(0.110)				(0.116)
Democracy				0.015**			0.013**
				(0.006)			(0.006)
War in next 10 years					0.027		0.023
					(0.118)		(0.134)
GDP per capita						0.002***	0.003*
						(0.001)	(0.002)
Size of the episode (% GDP)	-0.004*	-0.005**	-0.004	-0.004	-0.004*	-0.005**	-0.006**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
Length of the episode (years)	0.006	0.007	0.007	0.008	0.005	0.007	0.008
	(0.010)	(0.010)	(0.011)	(0.010)	(0.010)	(0.010)	(0.011)
Observations	124	114	121	114	124	124	104

Robust standard errors in parentheses. All results are obtained using an OLS specification and controlling for GDP growth in the next 2 or 10 years. An observation is an episode, defined using the tax per capita variables as explained above. See Appendix C for a description of the variables.

Table E.5: Determinants of revenue recovery after 2 years

	1	2	3	4	5	6	7
Density	0.010***						0.001
	(0.003)						(0.005)
Agr\ GDP		-0.005*					-0.002
		(0.003)					(0.004)
Capital openness			-0.141				-0.154
			(0.111)				(0.138)
Democracy				0.002			-0.003
				(0.006)			(0.007)
War this year or next					0.004		0.027
					(0.185)		(0.203)
GDP per capita						0.003***	0.002
						(0.001)	(0.002)
Size of the episode (% GDP)	-0.003	-0.002	-0.003	-0.002	-0.002	-0.004	-0.003
	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)
Length of the episode (years)	0.002	0.001	0.005	0.005	0.001	0.004	0.009
	(0.011)	(0.011)	(0.011)	(0.012)	(0.011)	(0.011)	(0.012)
Observations	127	117	124	117	127	127	107

Robust standard errors in parentheses. All results are obtained using an OLS specification and controlling for GDP growth in the next 2 or 10 years. An observation is an episode, defined using the tax per capita variables as explained above. See Appendix C for a description of the variables.

Table E.6: VAT as a determinant of revenue recovery

	1	2	3	4	5	6
VAT at time s	-0.015	-0.112				
	(0.092)	(0.108)				
VAT at time $s+10$			-0.050	-0.224***		
			(0.085)	(0.085)		
VAT created					-0.045	-0.154*
					(0.093)	(0.090)
Other determinants	No	Yes	No	Yes	No	Yes
Observations	124	104	124	104	124	104

Robust standard errors in parentheses. All results are obtained using an OLS specification and controlling for GDP growth in the next 2 or 10 years. An observation is an episode, defined using the tax per capita variables as explained above. See Appendix C for a description of the variables.