The Costs of Financial Crises:
Resource Misallocation, Productivity and Welfare in the 2001 Argentine Crisis

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ABSTRACT _____

Financial crises in emerging market countries appear to be very costly: both output and a host of partial welfare indicators decline dramatically. The magnitude of these costs is puzzling both from an accounting perspective – factor usage does not decline as much as output, resulting in large falls in measured productivity – and from a theoretical perspective. Towards a resolution of this puzzle, we present a framework that allows us to (i) *account* for changes in a country's measured productivity during a financial crises as the result of changes in the underlying technology of the economy, the efficiency with which resources are allocated across sectors, and the efficiency of the resource allocation within sectors driven both by reallocation amongst existing plants and by entry and exit; and (ii) *measure* the change in the country's welfare resulting from changes in productivity, government spending, the terms of trade, and a country's international investment position. We apply this framework to the Argentine crisis of 2001 using a unique establishment level dataset and find that more than half of the roughly 10% decline in measured total factor productivity can be accounted for by deteriorations in the allocation of resources both across and within sectors. We measure the decline in welfare to be on the order of one-quarter of one years GDP.

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1   Introduction

Financial crises in emerging market economies are costly: declines in economic activity are large, while a host of social indicators suggest that welfare falls substantially, too. For example, in the months surrounding the sovereign default and devaluation in Argentina at the end of 2001, output fell by 15%, down 20% from its previous peak, while unemployment exceeded 20% and almost half of the population fell below the poverty line. Large declines were observed also in the Asian Crisis economies in 1997 and 1998.[1]

Declines of this magnitude are hard to explain. From an accounting perspective, usage of factor inputs declines by less than output, resulting in a large decline in measured productivity. From a theoretical perspective, we have no theory as to why technology should regress during a crisis, and while measured productivity might decline due to declines in factor utilization, changes in utilization do not appear large enough to explain observed declines. Moreover, improvements in the terms of trade and write-offs of foreign debt increase a country's wealth partially offsetting the effect of the decline in productivity on welfare.

How much does welfare decline as a result of a financial crises? How much of this decline is the result of the decline in productivity? And what factors account for the decline in observed productivity? In this paper, we present a framework that allows us to *account* for observed changes in a country's productivity during a financial crises, and to *measure* the resulting change in the country's welfare. Specifically, we show how to decompose the change in an economy's measured productivity into changes in the efficiency with which resources are allocated across sectors, changes in the efficiency of the resource allocation within sectors driven both by reallocation amongst existing plants, as well as reallocation driven by both entry and exit, and changes in the underlying technology of the economy. We then show how to combine this measure with data on government spending, movements in the terms of trade, and in a country's international investment position, to measure the aggregate change in welfare of the economy.

We then apply this framework to the 2001 Argentine financial crisis using a unique dataset on the behavior of establishments throughout the crisis, combined with national accounting data. We find that the productivity of the Argentine economy fell by 11.5 per-cent between 1997 and 2001, when the crisis was at its peak, before recovering substantially in 2002. Of this decline,

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[1] Poverty rates more than doubled in Indonesia (Suryahadi et al 2000); domestic violence increased 20% in Malaysia (Shari 2001); child mortality rates increased 30% in Indonesia (Bhutta et al 2008); murders increased by 27.5% in Thailand (Knowles et al 1999); suicide rates increased 20% in Korea (Lee 2004).

we can account for more than half, as the result of a deterioration in the efficiency with which resources are allocated both across and within industries. Of this, the largest contributions come from deteriorations in the allocation of resources, and particularly labor, within industries.

We then measure the change in welfare induced by the crisis and find that the decline in welfare is equivalent to a one-quarter reduction in GDP in the year 1998. This is because the decline in welfare resulting from the reduction in measured productivity (from both increased misallocation and other sources) is offset by a combination of the change in the countries net foreign asset position, improvements in the prices at which it trades with the rest of the world, and tighter constraints on the governments ability to waste resources.

Our paper builds on several literatures. Like Chari, Kehoe and McGrattan (2005), Meza and Quintin (2005), Benjamin and Meza (2007), Kehoe and Ruhl (2006), Christiano, Gust and Roldos (2004), Neumeyer and Perri (2005), Mendoza (2006), Mendoza and Yue (2007), Arellano and Mendoza (2003) and Mendoza and Smith (2006), our paper aims to understand the consequences of international financial crises for output and productivity. Unlike all of these papers, our paper presents a framework for interpreting measured changes in economic activity as changes in welfare, and focuses on the role of distortions at a microeconomic level during the crisis in producing aggregate outcomes. Our paper is complementary to Gopinath and Neiman (2011) who find that variations in the availability of imported intermediate inputs during the Argentine crisis can explain a significant portion of the decline in aggregate productivity. Like Domar (1961), Weitzman (1976), and Basu and Fernald (2002) we study the relationship between measured productivity and welfare; unlike these papers, we consider an open economy with a government sector, and with arbitrary un-priced distortions to factor and goods markets. [2] Our emphasis on an open economy is shared by Hamada and Iwata (1984) and Kehoe and Ruhl (2007); unlike the latter, we study an economy with unbalanced trade, with a government, and with arbitrary unpriced distortions in goods and factor markets, while also analyzing the impact of the different measurement techniques for gross domestic product that are adopted in practice.

Like Solow (1957), Hulten (1978), Baily et al (1992), Basu and Fernald (2002), Petrin and Levinsohn (2005), and the work surveyed in Foster et al (2001), we study the relationship between technological progress at a plant level, reallocation of factors across plants, and aggregate tech-

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[2]Since writing the first draft of this paper, we have become aware of Basu et al (2009) who present a method for measuring the change in welfare of a stochastic open economy over time. Our paper differs in studying the change in welfare resulting from a financial crisis (and hence relative to an assumed path for the economy in the absence of a crisis), our focus on unpriced distortions to the allocation of factors, and our application to data.

nology; unlike these papers, we study the role of arbitrary distortions in generating gains from the reallocation of resources. Finally, our study of the role of distortions in the resource allocation mechanism in producing aggregate economic outcomes over time is related to Hall's (1988 and 1990) studies of the effect of imperfect competition on measured productivity, and to studies of the role of "wedges" at an aggregate level as in Cole and Ohanian (2005) and Chari, Kehoe and McGrattan (2006). Finally, in contrast to Restuccia and Rogerson (2003) and Hsieh and Klenow (2007) who study deviations from the *optimal* allocation of resources across plants within industries in different countries *at a point in time*, our paper studies the relative contribution of across industry reallocation, within industry reallocation among existing plants, and within industry reallocation induced by entry and exit, in producing changes in the *actual* allocation of resources for one country *over time*.

The rest of this paper is organized as follows. Section 2 outlines our framework for analyzing the productivity, output and welfare costs of international financial crises. Section 3 then derives the relationships between these objects as well as between these objects and empirical measures of output and productivity. We also show how several popular theoretical models fit into our framework. Section 4 describes our application of this framework to data on Argentina during the 2001/2002 financial crisis and presents our findings, while Section 5 concludes.

2 The Model

In this section we outline our framework for studying the impact of an international financial crisis on output, productivity and welfare. Rather than encoding a theory of a financial crisis, the model is intended as a measurement and accounting device: a number of exogenous variables, or "wedges", are introduced that are just identified by the data. The model then provides a framework for aggregating these wedges to account for observed changes in productivity and for measuring the (otherwise unobserved) change in welfare.

Consider a world that is deterministic; all agents in the economy have perfect foresight, except with regard to the advent of the international financial crisis which is modeled as an unforeseen event. The economy is small and open, taking world interest rates and the prices of its imports and exports as given; trade need not be balanced, so that the net foreign asset position of the country is evolving over time. There is a government that collects tax revenues and expends resources that may be valuable to households. There are many industries producing different goods, with these goods aggregated to form the national accounts expenditure categories. Production takes place in

3

plants that act competitively, each facing plant specific distortions – the "wedges" – that affect their incentive to produce at all, as well as to hire the various factors of production. These wedges stand in for a wide range of factors, that might be part of the technology of the economy, or the market environment, that drive a wedge between the price plants pay for a factor and the price received by the supplier of the factor; they allow us to capture a range of different economic environments including ones with imperfect competition.

2.A Households

There is a unit measure of identical households who maximize utility defined over streams of the single consumption good C, leisure $1 - L$, and government spending G, ordered by

$$W_t = \sum_{s=t}^{\infty} \beta^{s-t} \left[U\left(C_s, 1 - L_s\right) + \Gamma\left(G_s\right) \right],$$

where U is the period utility function that depends on private consumption and leisure, and Γ captures the welfare benefits (if any) of government expenditure. The assumption that households are identical implies that we can study the decisions of a representative households at the cost of not allowing us to consider the welfare effects of changes in the distribution of income.

Period t begins with the households owning B_t bonds and $\hat{K}_t$ capital. The household first decides how many investment goods to purchase, I_t, which cost P_{It} per unit, and then the entire $K_t = \hat{K}_t + I_t$ is devoted to production this period. The reason for allowing investment this period to affect the amount of capital devoted to production this period, is that we wish to allow the capital stock to respond to a crisis that occurs at the start of a period.

After capital is determined, labor supply decisions are made. Then all factors are paid and consumption occurs with the consumption good costing P_{Ct} per unit. What is left is carried forward into tomorrow as depreciated capital

$$\hat{K}_{t+1} = (1 - \delta) K_t = (1 - \delta) \left(\hat{K}_t + I_t\right),$$

and new bondholdings

$$B_{t+1} = P_{Lt} L_t + P_{Kt} \left(\hat{K}_t + I_t\right) + \Pi_t - T_t + (1 + r_{Bt}) B_t - \left(P_{Ct} C_t + P_{It} I_t\right).$$

Here Π_t represents any profits earned by plants which are returned to the household, T_t reflects

lump-sum transfers and taxes from the government, and r_{Bt} is the world interest rate, while P_{Lt} and P_{Kt} are the rental rates of labor and capital respectively. Government spending and transfers are treated as exogenous by the household.

The households problem is well defined and convex. If we let $W_t\left(\hat{K}_t, B_t\right)$ denote the value of the households problem at time t given inherited values of capital $\hat{K}_t$ and bonds B_t, then it is straightforward to show that the sequence of (time dependent) value functions satisfy

$$W_t\left(\hat{K}_t, B_t\right) = \max_{C_t, L_t, I_t, B_{t+1}} U\left(C_t, 1 - L_t\right) + \Gamma\left(G_t\right) + \beta W_{t+1}\left(\left(1 - \delta\right)\left(\hat{K}_t + I_t\right), B_{t+1}\right),$$

subject to

$$P_{Ct}C_t + P_{It}I_t + B_{t+1} \leq P_{Lt}L_t + P_{Kt}\left(\hat{K}_t + I_t\right) + \left(1 + r_{Bt}\right)B_t + \Pi_t - T_t,$$

with $\hat{K}_t$ and B_t given, and with B_t bounded below by some large (and non-binding) debt limit for all t to rule out Ponzi schemes. As the problem is convex, and under the usual differentiability assumptions on U, we can show that the W_t are differentiable. If we let λ_t denote the households shadow price of resources, the first order necessary conditions for an optimum include

$$
\begin{aligned}
u_L\left(C_t, 1 - L_t\right) &= P_{Lt}\lambda_t, \\
u_C\left(C_t, 1 - L_t\right) &= P_{Ct}\lambda_t, \\
\beta\frac{\partial W_{t+1}\left(\hat{K}_{t+1}, B_{t+1}\right)}{\partial B_{t+1}} &= \lambda_t, \\
\beta\frac{\partial W_{t+1}\left(\hat{K}_{t+1}, B_{t+1}\right)}{\partial \hat{K}_{t+1}} &= \lambda_t\frac{P_{It} - P_{Kt}}{1 - \delta},
\end{aligned}
\tag{1}
$$

while the envelope conditions are

$$
\begin{aligned}
\frac{\partial W_t\left(\hat{K}_t, B_t\right)}{\partial \hat{K}_t} &= \lambda_t P_{Kt} + \left(1 - \delta\right)\frac{\partial W_{t+1}\left(\left(1 - \delta\right)\left(\hat{K}_t + I_t\right), B_{t+1}\right)}{\partial \hat{K}_{t+1}}, \\
\frac{\partial W_t\left(\hat{K}_t, B_t\right)}{\partial B_t} &= \lambda_t\left(1 + r_{Bt}\right).
\end{aligned}
\tag{2}
$$

Note that, as the household faces undistorted market prices, these same market prices capture the marginal social costs and benefits of household decisions. This will be important in our welfare analysis below.

2.B Government

Government spending makes up a substantial fraction of GDP for most countries. As a result, our assumptions about how this spending is determined, and about how it is valued, can have a large impact on our estimates of welfare. In what follows, we examine two more-or-less polar cases. In both cases, this spending is financed by a combination of exogenously given distortionary taxes on plants (to be described below) and lump sum taxes. For simplicity we keep the governments budget balanced in each period through an appropriate choice of lump-sum taxes and transfers.[3]

In the first case, we treat government spending as *pure waste* so that $\Gamma(G_t) = 0$ for all t, with its level in each period exogenously given. In the second case, we allow the government to choose G_t *benevolently*. In this case, the government's choices satisfy $\Gamma'(G_t) = \lambda_t P_{Gt}$, where λ_t is the shadow price of the household introduced above and P_{Gt} is the price of one unit of the government expenditure good.

2.C Production of Basic Commodities

We consider an economy with J basic commodities produced in separate competitive industries. In each industry j, production takes place in plants of which there are a finite set of *types* indexed by i. A plant's type may evolve over time and denotes the level of its productivity, as well as the size of any distortions imposed on the plant in deciding whether to produce, and how much of each factor to hire. A plant of type i operating in industry j can sell it's output at the market price P_{Y_j} which it takes as given. In order to produce in a given period, the plant must pay a flow fixed cost F_j. We denominate these fixed costs in units of capital that we think of as the core buildings and structures within which production takes place. Once the fixed cost has been paid, the plant combines capital used for production K_i, labor L_i, and intermediate inputs Q_i to produce output according to a Cobb-Douglas production function

$$Y_i = A_i \left[K_i^{\alpha_j} L_i^{\beta_j} Q_i^{1-\alpha_j-\beta_j} \right]^{\gamma_j}.$$

Here A_i is the plant type i specific level of technology. We let A_j denote the efficient level of technology in industry j (the level that would arise if factors were allocated efficiently across plants; see Appendix 7 for a definition) and define τ_{Ai} such that $A_i = (1 - \tau_{Ai}) A_j$. The parameter γ_j is

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[3]This is without loss of generality because, in this model, for a given sequence of distortionary taxes, private borrowing will adjust to offset any path of government debt.

assumed to be less than one implying the existence of decreasing returns to scale at the plant level, which we use to pin down the scale of production at a plant.

Plants hire factors on competitive factor markets, taking factor prices as given. In the spirit of Chari, Kehoe and McGrattan's (2002) business cycle accounting, we posit the existence of plant specific *wedges* that distort the hiring decisions of a plant away from what would be chosen if all plants faced the same input prices. Specifically, if we let P_x denote the (common) market price of factor x for $x = K, L$, or Q, and τ_{xi} be the plant and factor specific wedge faced by a plant of type i in hiring factor x, then the effective price faced by a plant of type i is given by $P_x / (1 - \tau_{xi})$. A positive value of τ_{xi} can be thought of as a tax that increases the cost of the factor to the plant. We let τ_{Fi} capture any distortions to fixed costs which affect the incentive of a plant to produce in a given period. One could, in principle, also consider a wedge that affects the output price received by an individual plant. However, it is straightforward to see than an output wedge is equivalent to a constant wedge affecting all factor inputs and the fixed cost in the same way.

We interpret these wedges as a *stand-in* for all of the costs of hiring factors beyond the market price of the factor itself. Thus wedges may capture the presence of government taxes, adjustment costs to varying factors, or the effect of rationing due to quantity restrictions or borrowing constraints. Below, we will use data on actual factor employment decisions to identify the sizes and characteristics of these wedges, and will refer to *changes* in the size and pattern of these wedges as the impact of the financial crisis on the resource allocation mechanism.

A plant of type i in industry j that decides to produce in a period chooses factor inputs to maximize profits given by

$$
P_{Y_j} (1 - \tau_{A_i}) A_j \left[K_i^{\alpha_j} L_i^{\beta_j} M_i^{1 - \alpha_j - \beta_j} \right]^{\gamma_j}
$$
$$
- \frac{P_K}{1 - \tau_{Ki}} K_i - \frac{P_L}{1 - \tau_{Li}} L_i - \frac{P_Q}{1 - \tau_{Qi}} Q_i - \frac{P_K}{(1 - \tau_{Fi})(1 - \tau_{Ki})} F_j,
$$

so that the first order conditions for an optimum are

$$
\begin{aligned}
\alpha_j \gamma_j P_{Y_j} Y_i &= \frac{P_K}{1 - \tau_{Ki}} K_i, \\
\beta_j \gamma_j P_{Y_j} Y_i &= \frac{P_L}{1 - \tau_{Li}} L_i, \\
\left(1 - \alpha_j - \beta_j\right) \gamma_j P_{Y_j} Y_i &= \frac{P_Q}{1 - \tau_{Qi}} Q_i.
\end{aligned} \tag{3}
$$

During a financial crisis, there is often a great deal of turnover in the set of plants in operation.

To capture this feature of the data, we will need to allow for entry and exit in our model. We adopt a framework in which the decision to produce in a period is static so that, when taking the model to the data, we do not have to take a stand as to the plants expectations about future production decisions. Specifically, we assume that plants must pay the fixed cost $P_K F$ to produce in each period. After paying the fixed cost, plants then learn about their type i which is drawn from a (time and industry varying) distribution given by the probabilities π_i. We assume that the wedge on fixed costs, and that part of the wedge on capital that applies to fixed costs, are levied in lump sum fashion so that they do not affect the plants decision to produce *ex post*. Entry occurs as long as expected profits are positive, and so in equilibrium we must have

$$\sum_i \pi_i \left[\left(1 - \gamma_j\right) P_{Y_j} Y_i - \frac{P_K}{\left(1 - \tau_{Fi}\right)\left(1 - \tau_{Ki}\right)} F_j \right] = 0. \tag{4}$$

We let N_j denote the total number of plants that produce in industry j in a period. Our assumptions allow us to work with the data as though there were repeated cross sections of plants.

In this framework, if all plants in an industry faced the same wedges τ_{Ki}, τ_{Li}, and τ_{Qi}, *relative* (although not total) supply of output and usage of factors would be the same across plants in that industry. When we apply our framework to the data, it will be differences in supply and factor usage which will allow us to identify differences in wedges. Noting that as aggregate industry j output is given by

$$Y_j = N_j \sum_i \pi_i Y_i, \tag{5}$$

relative production is given by

$$\frac{P_{Y_j} Y_i}{P_{Y_j} Y_j} = \frac{Y_i}{Y_j} = \frac{(1 - \tau_{Ai})^{1/(1-\gamma_j)} \left[(1 - \tau_{KSi})^{\alpha_j} (1 - \tau_{Li})^{\beta_j} (1 - \tau_{Qi})^{1-\alpha_j-\beta_j}\right]^{\gamma_j/(1-\gamma_j)}}{N_j \sum_i \pi_i (1 - \tau_{Ai})^{1/(1-\gamma_j)} \left[(1 - \tau_{KSi})^{\alpha_j} (1 - \tau_{Li})^{\beta_j} (1 - \tau_{Qi})^{1-\alpha_j-\beta_j}\right]^{\gamma_j/(1-\gamma_j)}}$$

$$\equiv \frac{(1 - \tau_i)}{N_j \sum_i \pi_i (1 - \tau_i)}, \tag{6}$$

where we have defined $1 - \tau_i$ to be the *scale wedge* of a plant of type i given by the above geometric weighted average of the wedges on technology, capital services, labor and intermediate inputs.

Proceeding similarly for each factor, we obtain expressions for plant shares of industry factor usage

$$
\begin{aligned}
\frac{K_i}{K_j} &= \frac{(1 - \tau_i)(1 - \tau_{Ki})}{N_j \sum_i \pi_i (1 - \tau_i)(1 - \tau_{Ki})}, \\
\frac{L_i}{L_j} &= \frac{(1 - \tau_i)(1 - \tau_{Li})}{N_j \sum_i \pi_i (1 - \tau_i)(1 - \tau_{Li})}, \\
\frac{Q_i}{Q_j} &= \frac{(1 - \tau_i)(1 - \tau_{Qi})}{N_j \sum_i \pi_i (1 - \tau_i)(1 - \tau_{Qi})},
\end{aligned}
\tag{7}
$$

which verifies our intuition that a plant's relative demand for a factor depends in part upon its scale and in part upon the relative wedge it faces for that factor. Note that these expressions are homogenous of degree zero in the industry wide level of any one or combination of wedges; although the total amount of a factor hired by the industry may change, relative hiring decisions are unaffected by a common change in wedges in an industry.

Finally, it is convenient to note that, by aggregating the plants first order conditions we can obtain expressions for industry j factor shares as factions of the production parameters and output weighted average wedges

$$
\begin{aligned}
\frac{P_L L_j}{P_{Y_j} Y_j} &= \beta_j \gamma_j \sum_i \frac{P_{Y_j} Y_i}{P_{Y_j} Y_j} (1 - \tau_{Li}) \equiv \beta_j \gamma_j \left(1 - \bar{\tau}^Y_{Lj}\right), \\
\frac{P_Q Q_j}{P_{Y_j} Y_j} &= (1 - \alpha_j - \beta_j) \gamma_j \sum_i \frac{P_{Y_j} Y_i}{P_{Y_j} Y_j} (1 - \tau_{Qi}) \equiv (1 - \alpha_j - \beta_j) \gamma_j \left(1 - \bar{\tau}^Y_{Qj}\right).
\end{aligned}
\tag{8}
$$

Defining $\bar{\tau}^Y_{Kj}$ analogously, the residual from output after labor and intermediate goods have been paid is

$$
\begin{aligned}
\frac{P_{Y_j} Y_j - P_L L_j - P_Q Q_j}{P_{Y_j} Y_j} &= \frac{P_{Y_j} Y_j - P_L L_j - P_Q Q_j}{P_K K_j} \frac{P_K K_j}{P_{Y_j} Y_j} \\
&\equiv \mu_j \alpha_j \gamma_j \left(1 - \bar{\tau}^Y_{Kj}\right),
\end{aligned}
\tag{9}
$$

where μ_j is the ratio of revenues not paid to labor and intermediate inputs, to the payments made to capital, in industry j; if all wedges are zero in industry j, $\mu_j = 1$.

2.D Industries, Sectors and Aggregation

There are four final goods in the economy: an aggregate consumption good C, an investment good I, a government spending good G, and an export good X. In addition there is an aggregate intermediate input Q. Each of the final commodities plus the aggregate intermediate input are

produced using some combination of the J basic commodities along with the imported good M using a constant returns to scale technology that is operated by competitive undistorted plants. The technology for producing the final consumption good, for example, is represented by

$$C_t = H^C \left(C_{1t}, C_{2t}, ..., C_{Jt}, M_{Ct} \right),$$

where C_{jt} represents the amount of output from industry j, and M_{Ct} the amount of the import good, used for final consumption, and H^C is a homogenous of degree one function. Analogous homogeneous of degree one aggregators H^v exist for $v = I, G, X$, and Q. The constraints on the usage of each commodity j are given by

$$C_{jt} + I_{jt} + G_{jt} + X_{jt} + Q_{jt} \leq Y_{jt},$$

with use of the import good constrained by

$$M_{Ct} + M_{It} + M_{Gt} + M_{Xt} + M_{Qt} \leq M_t.$$

In what follows, we suppress the industry j subscript except when it would cause confusion.

The assumption of constant returns to scale combined with the assumption that these technologies are operated by competitive plants ensures that the price of each of these aggregates P_{vt} for $v = C, I, G, Q$ is a homogeneous of degree one function of the prices of the import good and each of the J basic commodities (as this is a small open economy, the prices of both exports P_{Xt} and imports P_{Mt} are given exogenously).

In practice, we will identify the prices of each of the national accounts expenditure aggregates with their corresponding implicit price deflators from the national accounts, and so we will not emphasize the properties of these aggregators. However, they are useful in thinking about the process of moving between the model and the data, and it is straightforward to show that a number of popular models fit into this framework:

Example 1. *One-Sector Closed Economy Without Frictions*

In this case, $N = 1$, $H^C(x, M) = H^I(x, M) = x$, and $H^G(x, M) = H^X(x, M) = H^Q(x, M) = 0$, while all of the $\tau's$ are equal to zero. It is common to assume that that plants operate with a constant returns to scale production function, in which case $\gamma = F = 0$ (although this is not necessary; see, for example, Rossi-Hansberg and Wright 2007).

Example 2. *One-Sector Closed Economy With Imperfect Competition and No Intermediate Inputs*

This is the framework studied by Hall (1988) and extended by Basu and Fernald (2001), and can be viewed as an extension of the previous case. Although the framework we have described above is competitive, the equilibrium allocations will be identical for an appropriate choice of $\tau_{Li} = \tau_{Ki} \neq 0$, reflecting the markup of price over marginal cost (which does not vary over factor inputs).

Example 3. *One-Sector Open Economy*

Abstracting from adjustment costs in capital, this is the model studied by Baxter and Crucini (1994) which is the same as our first case except $H^C(x, M) = H^I(x, M) = H^X(x, M) = x + M$, and $H^G(x, M) = H^Q(x, M) = 0$.

Example 4. *Open Economy With Imported Intermediate Inputs*

This is the case studied by Kehoe and Ruhl (2007) who also assume that labor supply and capital are fixed, so that $U(C, 1-L) = U(C)$, $\delta = 0$, and $H^I(x, M) = 0$, that trade is always balanced so that $P_X X = P_M M$ and $B_t = B_{t+1} = 0$, and that $H^C(x, M) = H^X(x, M) = x$, while $H^G(x, M) = 0$ and $H^Q(x, M) = M$. In a leading example, Kehoe and Ruhl specialize to a Leontieff production function between the labor-capital aggregate and imported intermediate inputs.

Example 5. *Two-Sector Open Economy*

This case captures the model studied by Backus, Kehoe and Kydland (1991) who assume that a country combines a single domestically produced good, that is also exported, with an imported good to produce an aggregate that is used for consumption, investment and government spending. In our framework, this translates to $H^X(x, M) = x$, and $H^C(x, M) = H^I(x, M) = H^G(x, M)$.

3   Measuring Misallocation During The Argentine Crisis of 2001

The model introduced above is intended as a device to (1) measure the changing efficiency of the resource allocation during a financial crisis; (2) account for the observed decline in measured productivity; and (3) measure the resulting change in welfare. In the next three sections we implement each of these steps in turn using data from Argentina around the crisis of 2001.

The Argentine crisis is a natural case to examine both because of its size and prominence, but also because of the greater availability of data for Argentina than for many other crisis countries. The crisis ended a decade of relative stability following the end of the hyperinflations of the late eighties and the adoption of a currency board in which the peso was pegged to the US Dollar. During the crisis, the government engaged in a series of debt restructuring negotiations that ended
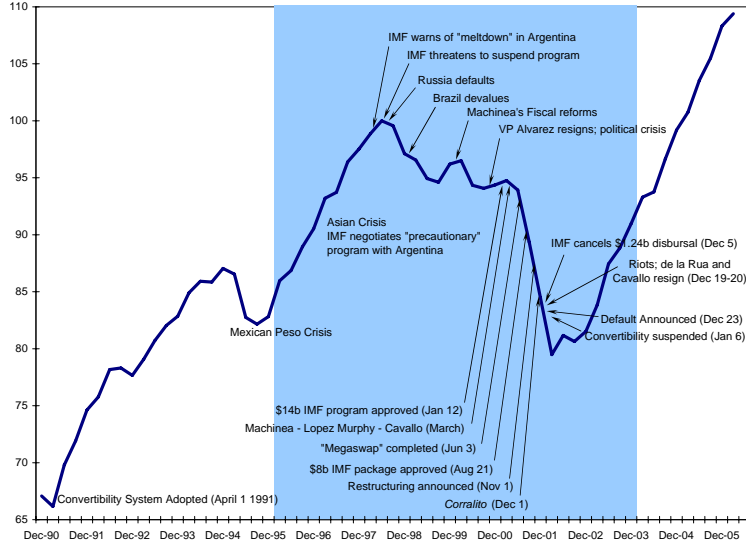
Figure 1: Timeline of the Argentine Crisis

in one of the largest sovereign defaults in history in December 2001. At the same time, there was a currency crisis that wiped out the convertibility regime (the currency board), a banking crisis, and a "sudden stop" in capital inflows.

This period was also associated with a dramatic decline in economic activity, as shown in Figure 1. Between the peak in the first quarter 1998 and trough in the first quarter of 2002, GDP declined by almost 20 per-cent in real terms, with the sharpest declines occurring in the last quarter of 2001 and the first quarter of 2002 when the quarterly changes in output were -5.7 and -5.0 per-cent respectively.

3.A   The Microeconomic Data

We obtained data on the performance of Argentine manufacturing establishments from the annual industrial survey (*Encuesta Industrial Anual*) carried out by the Argentine Institute of Statistics and Census (INDEC). This survey is conducted in March of each year; that is, the data for 2001 were collected in March of 2002, three months after the worst of the crisis. Inclusion of establishments in the survey is determined randomly within each of the 5 digit subsectors in the Central Product Classification of the United Nations. Each establishment is followed over time for as long as it continues operation, with disappearing establishments replaced using the same sampling techniques. New entrants to the survey that have been in existence for more than one year are distinguished from newly opened plants. The survey includes a sample of approximately

4,000 establishments for the period 1996-2002 taken from the universe of establishments with more than 10 workers. The universe of establishments with more than 10 workers constitutes only a small fraction of the number of establishments in the economy, but accounts for approximately 80% of employment and more than 80% of output in the manufacturing industry.[4]

The operational data provided by INDEC includes total wages, total hours worked, cost of inputs, interest payments, expenditures in electricity, gas and other energy sources, total expenditures, total sales in domestic and foreign markets (if any) and investment for each establishment including the change in inventories. No balance sheet data are collected, and so we do not have a direct estimate of the plants' capital stock. In order to preserve the anonymity of the respondents, INDEC transformed all variables into per worker terms and provided only a partial indicator of the plants employment: plants were classified as "small" if they had less than 80 workers, "medium" with between 80 and 200 workers, and "large" with more than 200 workers. However, INDEC did provide us with data on the growth rate of the number of workers, which allows us to capture the evolution of each of the variables of interest.

This absence of exact data on the level of employment has no effect on the calculation of the wedges (the $\tau's$) reported below; it only affects the process by which we aggregate these results to form conclusions about aggregate productivity in the next section. For this, we need an estimate of the number of employees in each plant. We experimented with several methods for imputing establishment size. For our benchmark method, we assume that each establishment has in 1996 – the first year of our sample – a number of workers equal to the midpoint of its size bin for small and medium plants (45 workers for small plants, 140 for medium size ones). For the following years we compute the number of workers for each establishment using the rate of variation in the number of workers. Whenever this method yielded, for a subsequent year, a number of workers that is inconsistent with the size category reported for that plant, we adjust the initial number of workers to place the establishment at the boundary of that size category. For large plants that do not change size categories we set their number of workers so that we obtain the aggregate level of employment of plants in the sample from the aggregated data. Except where noted in the text, and as discussed in the appendix, our results are robust to a number of alternative methods for imputing establishment size. Moreover, as shown in the appendix, our method yields aggregate data that closely match the performance of the manufacturing sector.

In order to bring the production side of the model to the data we need to calibrate the

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[4]Employment in the manufacturing sector accounts for approximately 20% of total employment.

values of the production function parameters. We use industry aggregate data for Argentina for the year 1997 to compute $\alpha_j \gamma_j$ and $\beta_j \gamma_j$ (and hence also $\left(1 - \alpha_j - \beta_j\right) \gamma_j$) for each year under the assumption that wedges are zero in 1997.[5] We assume that the decreasing returns to scale parameter $\gamma_j = 0.9$ for all j, which is in the neighborhood of estimates computed by Atkeson, Khan and Ohanian (1996). For the purposes of calculating the wedges for each sector, however, all we need to do is to compare factor usage at each plant with their average usage in the industry. The only exception are the productivity wedges τ_{Ai}. For this we calculate for each plant

$$A_i = A_j \left(1 - \tau_{Ai}\right) = \frac{Y_i}{\left[K_i^\alpha L_i^\beta Q_i^{1-\alpha-\beta}\right]^\gamma}.$$

This poses two challenges with our dataset as we do not observe directly the stock of capital, or establishment level output and input prices.[6] First, given the short period of time we are studying, it is unlikely that the capital stock changed significantly. However, it is very likely that the intensity with which capital was used varied throughout the crisis. We describe in the next subsection how we use information on energy consumption at each plant to measure variations in capital utilization. Second, as we do not observe plant specific prices nor the real quantity of output, we use average industry prices from IPIB for each manufacturing subsector to recover output from the value of sales. And, as we do not observe plant specific input prices we use aggregate input prices from INDEC's wholesale price index (IPIB: Índice de Precios Internos Básicos) to recover the quantities of of energy utilization, and intermediate inputs, from the data on expenditures in energy and the cost of inputs.[7] As the same input and output prices are used for all plants in an industry, they have no effect on the distribution of relative wedges within that industry.

3.B   Capital and Capital Services

Capital utilization is likely to have varied throughout the crisis. In addition, our establishment level dataset does not include the balance sheet of the plant, and so we do not have estimates of the book-value of the plants capital stock. Hence, we assume that capital devoted to production is

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[5]As a robustness check we compute these parameters also using US data. Our results remain essentially unchanged.

[6]As explained above, we use our estimate of employment to compute an estimate of hours worked.

[7]Since inputs can be imported or produced domestically, we first obtain the industry shares of imported and domestic inputs using INDEC's input-output matrix from 1997, and then construct an industry average input price from IPIB prices.

used to produce *capital services* KS using a Leontieff production function of the form

$$KS_i = \min \left\{ E_i, \frac{1}{\theta} K_i \right\},$$

where E_i refers to purchases of *energy*, which is introduced as the $J + 1$'th primary commodity, and $1/\theta$ captures the number of units of energy required to power one unit of physical capital which we assume is common across plants and sectors. We continue to assume that fixed costs are denominated in terms of capital, and not capital services. Then if the cost of energy and capital rental, and their wedges, are given by P_E, P_K, τ_{Ei}, and τ_{Ki}, respectively, the market price of a unit of capital services is

$$P_{KS} = P_E + \theta P_K,$$

and we can define the wedge on capital services as a whole, τ_{KSi}, so that it satisfies

$$\frac{P_{KS}}{1 - \tau_{KSi}} \equiv \frac{P_E}{1 - \tau_{Ei}} + \theta \frac{P_K}{1 - \tau_{Ki}}.$$

Hence, we can identify the capital wedge up to a constant (that is constant across plants and sectors at a point in time) from

$$\left(1 - \bar{\tau}_{KSm}^Y\right) \left(1 - \frac{\theta P_K}{P_E + \theta P_K}\right) = \frac{1}{\alpha_m \gamma_m} \frac{P_E E_m}{P_Y Y_m}.$$

The other plant level wedges can be obtained in a similar way from the equations in (3) above.

3.C   Results

The following figures show the distribution of establishment productivity for surviving firms in the sample for the years 1997, 1998 and 2002. The top and bottom 1% of observations were excluded. We observe that between the relatively normal years of 1997 and 1998, there was little change in this distribution. However, when comparing 2002 to 1997, we see that there was a marked fattening of both tails of the distribution.

The next three sets of figures present the analogous pictures for the different factor wedges. In the first set, we see that there was a fattening of the left tail in the labor wedge distribution between 1997 and 1998. Negative wedges suggest establishments are retaining more workers than desired, which possibly reflects an increase in labor hoarding between these years. However, at the same time there was an increase in the density in the middle of the distribution. Between 1998 and 2002,
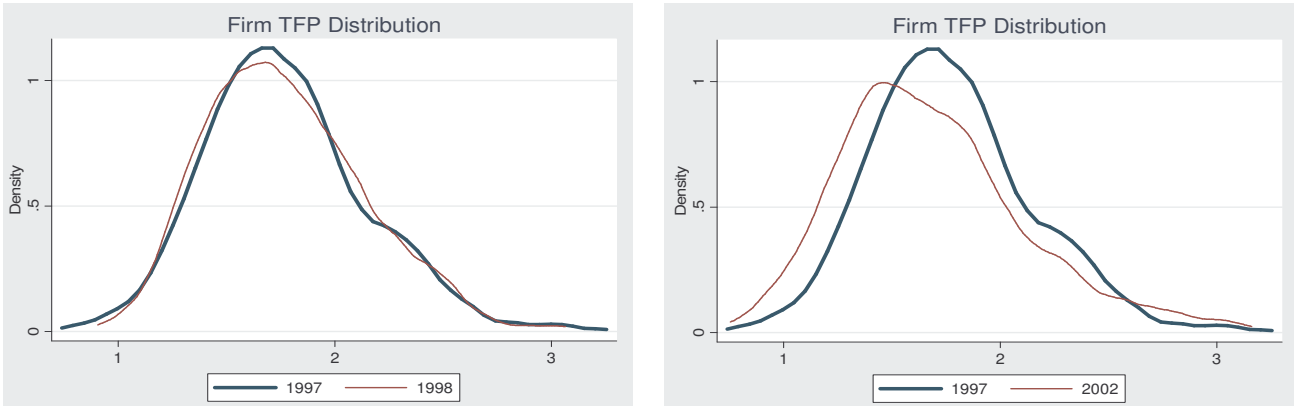
Figure 2: Distribution of Total Factor Productivity in 1997, 1998 & 2002

there was a substantial fattening of both of the tails of the distribution. This is consistent with a large decline in the efficiency with which labor is allocated, with those establishments with negative wedges wishing to reduce employment, and those with positive wedges wanting to increase their employment. By contrast, the movements in the capital and intermediate input wedge distributions are more modest.[8]
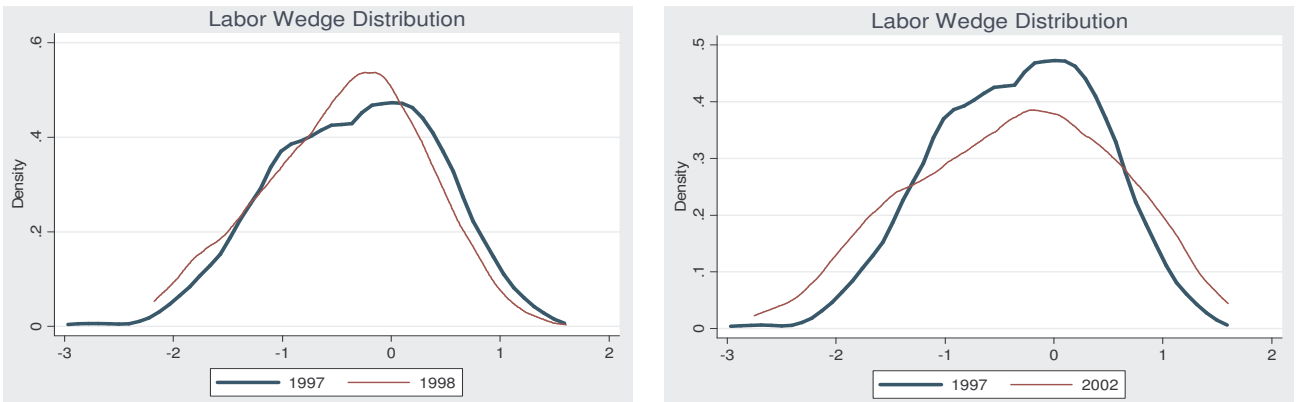

Figure 3: Distribution of Labor Wedge in 1997, 1998 & 2002

The following table presents some descriptive statistics for the joint distribution of wedges and productivity in Argentina. The table shows that mean total factor productivity falls by 5%, while the mean labor wedge rises, suggesting that on average establishments face more difficulty increasing their employment of labor. Both the wedges for capital and intermediate inputs fall slightly on average.

Dispersion in productivity as well as both the labor and capital wedges also increase, with

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[8]We find similar patterns if we analyze deviations with respect to industry means.
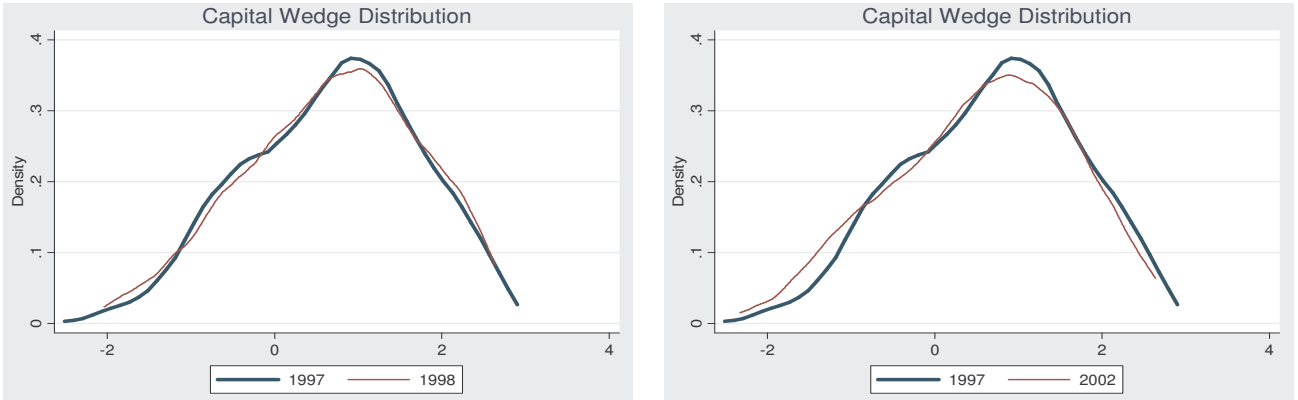
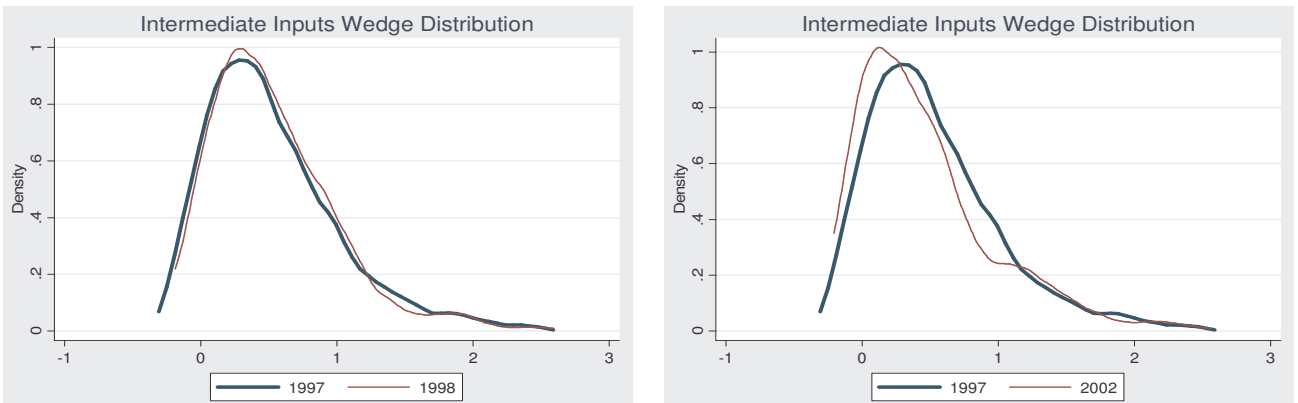Figure 4: Distribution of Capital Wedge in 1997, 1998 & 2002

Figure 5: Distribution of Intermediate Input Wedge in 1997, 1998 & 2002

the largest changes observed for the labor wedge. Dispersion in the intermediate wedge falls. Both the labor and intermediate input wedges become more correlated with output suggesting that the most efficient establishments become more constrained in their ability to increase employment of these factors, while the correlation with the capital wedge declines.

In the next section, we examine the consequences of these changes in the allocation of resources across plants for aggregate productivity.

4   Accounting For Changes in Aggregate Productivity

In this section, we examine the extent to which changes in the allocation of resources account for the changes in aggregate output and productivity.

	A_i	$\frac{1}{(1-\tau_{Li})}$	$\frac{1}{(1-\tau_{Ki})}$	$\frac{1}{(1-\tau_{Qi})}$
		1997		
Mean	6.35	0.93	1.95	3.15
Std Dev	2.76	0.68	1.35	3.02
90-10	6.12	1.58	2.17	7.25
75-25	2.70	0.87	1.01	3.25
Correlation with A_i	1.00	0.12	0.80	0.23
		2002		
Mean	6.00	1.03	1.87	2.91
Std Dev	3.21	0.92	1.43	2.88
90-10	6.35	2.12	2.35	6.56
75-25	2.82	1.07	0.88	3.10
Correlation with A_i	1.00	0.31	0.76	0.38

Table 1: Distribution of Wedges and Productivity in Argentina

4.A From Plant to Industry Output

Gross output of an industry is simply the sum of the gross output of each plant in the industry (5). Ignoring the distinction between capital and capital services for the moment, and using the form of the production function and our formulae for the allocation of factors across plants (7) we obtain an expression for industry output as a function of industry factor usage

$$Y_j = \Phi_j A_j \left[K_j^{\alpha_j} L_j^{\beta_j} Q_j^{1-\alpha_j-\beta_j} \right]^{\gamma} N_j^{*1-\gamma}, \tag{10}$$

where

$$
\Phi_j = \sum_i \pi_i \left\{ (1 - \tau_{Ai}) \left(\frac{(1-\tau_{Ki})(1-\tau_i)}{\sum_{i\in j} \pi_i (1-\tau_{Ki})(1-\tau_i)} \right)^{\alpha_j\gamma} \left(\frac{(1-\tau_{Li})(1-\tau_i)}{\sum_{i\in j} \pi_i (1-\tau_{Li})(1-\tau_i)} \right)^{\beta_j\gamma} \times \right.
$$
$$
\left. \left(\frac{(1-\tau_{Qi})(1-\tau_i)}{\sum_{i\in j} \pi_i (1-\tau_{Qi})(1-\tau_i)} \right)^{(1-\alpha_j-\beta_j)\gamma} \right\}, \tag{11}
$$

captures the effect of the wedges on the allocation of resources and its impact on industry output. Equation 10 establishes that industry j output is a constant returns to scale function of the inputs devoted to production, K_j, L_j, and Q_j, and the number of firms N_j; that is, it is as though the number of firms is an extra factor of production.

Rearranging the free entry condition (4) we find that the number of firms in an industry is a linear function of industry output of the form $N_j^* = \Lambda_j Y_j$ where

$$\Lambda_j \equiv \frac{1-\gamma}{P_K F/P_{Yj}} \sum_{i \in j} \pi_i \frac{1}{(1-\tau_{Fi})(1-\tau_{Ki})}.$$

This expression is quite intuitive: if fixed costs $P_K F/P_Y$ are large, or returns to scale are close to constant ($\gamma \approx 1$), it is optimal for only a small number of plants to produce, and the number of plants does not vary with output. Substituting this expression into (10) and rearranging yields

$$Y_j = \left(A_j \Phi_j \Lambda_j^{(1-\gamma)} \right)^{1/\gamma} K_j^{\alpha_j} L_j^{\beta_j} Q_j^{1-\alpha_j-\beta_j}. \tag{12}$$

Equations (10) and (12) constitute a statement of Viner's classic result: even though there are decreasing returns at the plant level, with free entry the industry acts as though it has constant returns to scale by varying the number of plants in operation, each of which produces at the minimum of its (expected) average cost curve.

4.B Industry Productivity and Intra-Industry Misallocation

Equation (12) also shows that, if we know the output elasticities α_j and β_j, and calculate measured industry productivity, $\hat{A}_j$, by dividing gross output by the output-elasticity-geometric-weighted-average of factor inputs, we obtain

$$\hat{A}_j = \left(A_j \Phi_j \Lambda_j^{(1-\gamma)} \right)^{1/\gamma}.$$

That is, measured industry productivity depends on: the fundamental level of total factor productivity in the industry A_j; a term Φ_j that captures the efficiency of the allocation of resources across plants with different productivities τ_{Ai}, and its misallocation caused by the different costs of hiring factors τ_{Ki}, τ_{Li}, and τ_{Qi}; and a term Λ_j which captures the efficiency with which the number of plants in the industry varies.

To illustrate the role of allocative inefficiency in determining industry j measured productivity, differentiate (11) with respect to time to show that changes in Φ_j are the result of two effects:

First, the effect of reallocation between existing plant types, which we denote by

$$
\begin{aligned}
R_{1j} &= \sum_{i \in j} \frac{\pi_i^* Y_i}{\overline{Y}_j} \frac{d(1 - \tau_{Ai})}{(1 - \tau_{Ai})} + \alpha_j \gamma \sum_{i \in j} \pi_i \left(\frac{Y_i}{\overline{Y}_j} - \frac{K_i}{\overline{K}_j} \right) \left(\frac{d(1 - \tau_i)}{(1 - \tau_i)} + \frac{d(1 - \tau_{Ki})}{(1 - \tau_{Ki})} \right) \\
&\quad + \beta_j \gamma \sum_{i \in j} \pi_i \left(\frac{Y_i}{\overline{Y}_j} - \frac{L_i}{\overline{L}_j} \right) \left(\frac{d(1 - \tau_i)}{(1 - \tau_i)} + \frac{d(1 - \tau_{Li})}{(1 - \tau_{Li})} \right) \\
&\quad + (1 - \alpha_j - \beta_j) \gamma \sum_{i \in j} \pi_i \left(\frac{Y_i}{\overline{Y}_j} - \frac{Q_i}{\overline{Q}_j} \right) \left(\frac{d(1 - \tau_i)}{(1 - \tau_i)} + \frac{d(1 - \tau_{Qi})}{(1 - \tau_{Qi})} \right) ;
\end{aligned}
$$

Second, the effect of changes in the composition of plant types, which we denote by

$$
R_{2j} = \sum_{i \in j} \pi_i \left(\frac{Y_i}{\overline{Y}_j} - \alpha_j \gamma \frac{K_i}{\overline{K}_j} - \beta_j \gamma \frac{L_i}{\overline{L}_j} - (1 - \alpha_j - \beta_j) \gamma \frac{Q_i}{\overline{Q}_j} \right) \frac{d\pi_i^*}{\pi_i^*}.
$$

To understand R_{1j}, it is useful to consider a number of thought experiments. First, suppose that there are no factor distortions, so that at each plant all factor ratios equal the output ratio, and

$$
R_{1j} = \sum_{i \in j} \pi_i \frac{Y_i}{\overline{Y}_j} \frac{d(1 - \tau_{Ai})}{(1 - \tau_{Ai})}.
$$

If all plants start with the same technology level ($\tau_{Ai} = 0$ for all i) so that all firms are of the same size ($Y_i = \overline{Y}_j$), and there is a mean preserving spread in the distribution of τ_{Ai}'s, there is no effect on industry measured TFP; this is a consequence of the envelope theorem. If, however, some plants begin with different TFP levels, the effect of a mean preserving change in the distribution of τ_{Ai}'s depends on whether the variance of the distribution of productivity increases (in which case the most efficient plants, $Y_i > \overline{Y}$, become more productive $d(1 - \tau_{Ai}) > 0$ so that $R_1 > 0$) in which case productivity rises, or the variance decreases (the least efficient plants, $Y_i < \overline{Y}$, become more productive $d(1 - \tau_{Ai}) > 0$ so that $R_1 < 0$) in which case productivity falls. In other words, there is a tendency for *increases in the variance of productivity levels to increase aggregate productivity* as production is reallocated towards the most efficient plants.

Second, suppose that all plants have the same scale ($\tau_{Ai} = \tau_i = 0$ for all $i \in j$), but that there are relative factor price distortions. This places a strong restriction on relative movements in the wedges on each factor, and so for simplicity we assume that the wedges on L are unchanged at zero and examine changes in the wedges on intermediate inputs and capital. Then we must have

$$
\frac{d(1 - \tau_{Ki})}{(1 - \tau_{Ki})} = \frac{-(1 - \alpha_j - \beta_j)}{\alpha_j} \frac{d(1 - \tau_{Qi})}{(1 - \tau_{Qi})}.
$$

so that

$$R_{1j} = \left(1 - \alpha_j - \beta_j\right) \gamma \sum_{i \in j} \pi_i \left(\frac{K_i}{\overline{K}_j} - \frac{Q_i}{\overline{Q}_j}\right) \frac{d\left(1 - \tau_{Q_i}\right)}{\left(1 - \tau_{Q_i}\right)}.$$

In this case, the largest users of intermediate inputs are also the smallest users of capital, and vice versa. If the variance of the distribution of wedges on intermediate inputs increases, then $d\left(1 - \tau_{Q_i}\right) > 0$ for plants with $K_i/\overline{K}_j - Q_i/\overline{Q}_j < 0$ and industry productivity falls. This result holds more generally, allowing us to conclude that there is a tendency for *increases in the variance of factor wedges to decrease aggregate productivity.*

To understand R_{2j}, note that by definition, $\sum_{i \in j} d\pi_i^* = 0$, and so if all plants were identical $R_{2j} = 0$. When there is heterogeneity, however, everything else equal, an increase in the share of types producing above average amount of output increases productivity ($R_{2j} > 0$) as this represents an increase in the share of the most productive plants. Conversely, everything else equal, an increase in the share of the largest factor users reduces productivity ($R_{2j} < 0$) as this represents an increase in the most distorted plants.

Next, to understand the role of changes in the efficiency of plant turnover in producing industry productivity, note that

$$\frac{d\Lambda_j}{\Lambda_j} = \frac{dP_{Yj}}{P_{Yj}} - \frac{dP_{Kj}}{P_{Kj}} + \sum_{i \in j} \left(\frac{d\pi_i}{\pi_i} - \frac{d\left(1 - \tau_{Fi}\right)}{\left(1 - \tau_{Fi}\right)} - \frac{d\left(1 - \tau_{Ki}\right)}{\left(1 - \tau_{Ki}\right)}\right) \frac{\pi_i}{\left(1 - \tau_{Fi}\right)\left(1 - \tau_{Ki}\right)}.$$

These terms reflect the consequences of decreasing returns at a plant level for industry productivity. If the price of capital rises faster than the price of output, real fixed costs rise and variations in output are met with smaller changes in the number of plants and larger increases in incumbent plant production, which reduces industry productivity because of decreasing returns. On the other hand, if fixed costs fall, or there is a shift in the distribution of plants towards those with lower fixed costs, productivity is increased.

Another issue that arises is related to the fact that we are using the variation in the consumption of power to capture changes in the amount of capital services utilized by the plant. In some practical applications this might not be possible, and it would be necessary for the researcher to allow for the fact that we typically cannot distinguish between an increase in total capital from an increase in capital used in production. Combining the definition of aggregate capital with the free entry condition (4) and the plant's first order condition in capital services from (3) yields the

relationship between total capital K_T and capital in production K in an industry as

$$K_T = \left(1 + \Lambda \frac{P_K F}{P_Y} \frac{1}{\alpha\gamma} \frac{\sum_i \pi_i \left(1 - \tau_i \right)}{\sum_i \pi_i \left(1 - \tau_i \right) \left(1 - \tau_{Ki} \right)} \right) K \equiv \left(1 + \Lambda\Gamma \right) K \equiv \kappa K, \qquad (13)$$

so that

$$\frac{dK_T}{K_T} = \frac{dK}{K} + \frac{d\kappa}{\kappa}.$$

That is, total capital demand will grow faster than total capital used in production if either more firms enter at lower scale $(d\Lambda/\Lambda > 0)$ or if there is a relative reduction in the use of capital per unit of output produced $(d\Gamma/\Gamma > 0)$.

When data on power consumption is available, the analysis is modified in two ways. First, purchases of energy must now be subtracted from gross output to compute value added. Second, the relationship between total capital in an industry K_{Tj}, and capital services devoted to production in that industry KS_j is now given by

$$K_{Tj} = \frac{P_{KS}}{P_K} \kappa KS_j = \hat{\kappa} KS_j,$$

so that

$$\frac{d\hat{\kappa}}{\hat{\kappa}} = \left(\frac{dP_{KS}}{P_{KS}} - \frac{dP_K}{P_K} \right) + \frac{d\kappa}{\kappa}.$$

Now, if the price of energy rises making the price of capital services rise faster than the price of capital, the ratio of capital to capital services in the industry rises.

4.C Aggregate Productivity and Inter-Industry Misallocation

Finally, we use our measures of productivity at the plant and industry levels to obtain measures of aggregate productivity. As we will see below when we discuss welfare, and has been stressed by other authors, the appropriate measure of productivity growth for welfare purposes takes the growth rate of value added and subtracts the growth rates of capital and labor weighted by factor shares computed using the social cost of supplying those factors. In the framework introduced above, we assumed that households receive the undistorted capital and labor prices, and hence we should weight factor input growth by their simple factor shares, resulting in the traditional definition of total factor productivity of the economy that we denote TFP_1. If this assumption is not satisfied, we would need to adjust our welfare measure with terms that multiply the change in the aggregate supply of capital and labor by the deviation of market prices from social costs.

In practice, the capital share of income is difficult to measure due to the possible presence of fixed costs and pure profits. As a result, the large falls in TFP observed during most emerging market financial crises have been measured using a version of Solow's (1957) residual in which the capital share is approximated by the non-labor share of income

$$\frac{dTFP_2}{TFP_2} = \frac{dV}{V} - \left(1 - \omega_L^Y\right)\frac{dK}{K} - \omega_L^Y \frac{dL}{L}, \tag{14}$$

which we denote TFP_2.

To connect our aggregate measures of TFP with our industry and plants level discussion of technology growth, note that aggregate value added (or GDP) is simply the sum of value added in each industry j

$$P_V V = \sum_j P_{V_j} V_j,$$

and hence the growth rate of real GDP is given by the value added weighted average growth rates of industry value added

$$\frac{dV}{V} = \sum_j \frac{P_{V_j} V_j}{P_V V} \frac{dV_j}{V_j}.$$

To compute the aggregate Solow residual, we will need to subtract aggregate factor share weighted averages of aggregate inputs. For labor, note that

$$\omega_L^Y \frac{dL}{L} = \sum_j \omega_j^Y \omega_{Lj}^Y \frac{dL_j}{L_j},$$

where ω_j^Y is industry j's share of aggregate value added. For capital, the measurement issues surrounding the capital share lead to a more complicated relationship

$$
\begin{aligned}
\left(1 - \omega_L^Y\right)\frac{dK}{K} &= \sum_j \omega_j^Y \left(1 - \omega_{Lj}^Y\right) \frac{P_K K_j}{P_K K} \frac{P_V V - P_L L}{P_V V_j - P_L L_j} \frac{dK_j}{K_j} \\
&= \sum_j \omega_j^Y \left(1 - \omega_{Lj}^Y\right) \frac{\bar{\mu}}{\mu_j} \frac{dK_j}{K_j},
\end{aligned}
$$

where

$$\bar{\mu} = \frac{P_V V - P_L L}{P_K K}.$$

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Hence, in general, the aggregate Solow residual is given by

$$\frac{dTFP_2}{TFP_2} = \sum_j \omega_j^Y \left(\frac{dV_j}{V_j} - \left(1 - \omega_{Lj}^V\right) \frac{\bar{\mu}}{\mu_j} \frac{dK_j}{K_j} - \omega_{Lj}^Y \frac{dL_j}{L_j} \right),$$

which is the value added weighted average of the growth in industry Solow residuals adjusted for the capital share measurement issues discussed above.[9]

Finally, to connect with industry and plant level data, which is presented in terms of gross output, and our aggregate data using value added, note that the definition of value added implies that

$$\frac{dY_j}{Y_j} = \frac{P_{V_j} V_j}{P_{Y_j} Y_j} \frac{dV_j}{V_j} + \frac{P_Q Q_j}{P_{Y_j} Y_j} \frac{dQ_j}{Q_j} = \omega_{Vj}^Y \frac{dV_j}{V_j} + \omega_{Qj}^Y \frac{dQ_j}{Q_j}. \tag{15}$$

Hence we can rewrite our expression for the growth rate of the aggregate Solow residual as

$$\frac{dTFP_2}{TFP_2} = \frac{1}{\omega_V^Y} \sum_j \omega_j^Y \left\{ \frac{dY_j}{Y_j} - \left(1 - \omega_{Lj}^V\right) \omega_{Vj}^Y \frac{\bar{\mu}}{\mu_j} \frac{dK_j}{K_j} - \omega_{Lj}^Y \frac{dL_j}{L_j} - \omega_{Qj}^Y \frac{dQ_j}{Q_j} \right\}. \tag{16}$$

Substituting for the change in output in (16) by taking the derivative of equation (12), substituting for industry factor shares from (8) and (9), replacing the change in capital used in production by the change in total capital from (13), and rearranging, we obtain that the growth in the Solow residual $dTFP_2/TFP_2$ is given by

$$\frac{1}{\omega_Y^V} \sum_j \omega_Y^j \left\{ \frac{1}{\gamma_j} \frac{dA_j}{A_j} + \frac{1}{\gamma_j} \left(\frac{d\Phi_j}{\Phi_j} + \left(1 - \gamma_j\right) \frac{d\Lambda_j}{\Lambda_j} \right) - \alpha_j \frac{d\kappa_j}{\kappa_j} \right. \tag{17}$$

$$+ \alpha_j \left(1 - \gamma_j \left(1 - \bar{\tau}_K\right) \bar{\mu}\right) \frac{dK_j}{K_j} + \beta_j \left(1 - \gamma_j \left(1 - \overline{\tau}_L\right)\right) \frac{dL_j}{L_j} + \left(1 - \alpha_j - \beta_j\right) \left(1 - \gamma_j \left(1 - \overline{\tau}_Q\right)\right) \frac{dQ_j}{Q_j}$$

$$\left. + \alpha_j \gamma_j \left(\overline{\tau}_{Kj} - \overline{\tau}_K\right) \frac{dK_j}{K_j} + \beta_j \gamma_j \left(\overline{\tau}_{Lj} - \overline{\tau}_L\right) \frac{dL_j}{L_j} + \left(1 - \alpha_j - \beta_j\right) \gamma_j \left(\overline{\tau}_{Qj} - \overline{\tau}_Q\right) \frac{dQ_j}{Q_j} \right\},$$

where $\overline{\tau}_K, \overline{\tau}_L$ and $\overline{\tau}_Q$ are the output weighted average wedges on capital, labor and intermediate inputs across industries.

This equation decomposes the change in the traditional Solow residual TFP into five components. The first line of this equation captures three components: a weighted average of industry

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[9]If $P_K K_j = P_V V_j - P_L L_j$, then this expression reduces to the value added weighted growth rate of industry Solow residuals

$$\frac{dTFP_1}{TFP_1} = \sum_j \omega_j^Y \left(\frac{dV_j}{V_j} - \left(1 - \omega_{Lj}^V\right) \frac{dK_j}{K_j} - \omega_{Lj}^V \frac{dL_j}{L_j} \right).$$

technology growth; the misallocation *within* sectors, including any misallocation resulting from entry and exit; and the mismeasurement that results when we use the growth rate of aggregate capital instead of the growth rate of capital used in production. The second line captures the effect of mismeasuring output elasticities in the computation of the Solow residual.

The third line is new and captures the effect of the changing misallocation of factors *across* sectors. This term will be zero if either there is no inter-industry reallocation occurring (so that $dK_j/K_j = dL_j/L_j = dQ_j/Q_j = 0$ for all j), or if marginal products are equated across industries (so that $\bar{\tau}_{Kj} = \bar{\tau}_K$, $\bar{\tau}_{Lj} = \bar{\tau}_L$, and $\bar{\tau}_{Qj} = \bar{\tau}_Q$ for all j). Otherwise, the changing allocation of resources across sectors will affect measured aggregate productivity. To see this, take the example of labor. If, as a result of different wedges in different industries, labor has a higher marginal product in industry j than on average (or $\bar{\tau}_{Lj} > \bar{\tau}_L$) a reallocation of labor to this industry, and away from lower marginal product industries, will increase the Solow residual.

4.D   Results

Ideally, to apply the above methodology to Argentine data, we should possess plant level data for the entire economy which could then be compared with national accounts data. However, our plant level data covers only the manufacturing sector. In addition, Argentine national accounts data (in common with the data for many other countries) are subject to potentially serious measurement error due to the widespread use of the single deflation method in constructing estimates of aggregate value added. We discuss these issues in more detail in an appendix, and simply note for now that, as a consequence of these concerns we focus entirely on estimates for the manufacturing sector derived from our sample data, treating our sample as representative of both the entire manufacturing sector, and of the entire Argentine economy.

Table : Accounting For The Fall in Argentine Productivity

All Plants					
	Change From 1997 (% Chained)				
	1998	1999	2000	2001	2002
Manufacturing Total Factor Productivity (TFP_2)	-7.45	-6.06	-3.45	-11.45	-5.88
Intra Industry Misallocation	-3.66	-1.67	-0.47	-7.28	-1.96
Inter Industry Misallocation	-0.47	0.57	1.01	-0.17	-1.19
Residual (Technology and Mismeasurement)	-3.32	-4.96	-4.09	-4.00	-2.73

Table 4.D reports the change in Solow residual derived from our data, and decomposes the sources of its changes into four main components. The change in each component from one year to the next was calculated at an industry level, aggregated using the Tornqvist approximation to the Divisia index and then chained to produce an estimate of the change relative to 1997. The results were robust to using a Fisher Ideal index.

As shown in the Table, our measure of the Solow residual drops dramatically in 1998 before recovering somewhat in 1999 and 2000, only to drop dramatically once again in 2001 reaching a trough of 11.45% below its previous peak. The Solow residual then recovers sharply in 2002 mirroring the sharp recovery in the entire economy. The contribution of intra-sector misallocation mirrors this pattern, explaining half of the initial decline in 1998, producing almost all of the decline between 2000 and 2001, and accounting for roughly two-thirds of the cumulative decline in the Solow residual to that point. A recovery in intra-industry misallocation in 2002 results in this item accounting for slightly more than one-third of the entire movement in the Solow residual between 1997 and 2002.

The contribution of inter-industry misallocation is more modest with the exception of between 2001 and 2002 where it led to a full percentage point decline in the Solow residual and ends up accounting for one-fifth of the entire change between 1998 and 2002. It total, our methodology finds that changes in the allocation of resources account for almost two-thirds of the decline in the Solow residual from the previous peak in 1997 to the trough of the crisis in 2001, and more than half of the decline up to 2002. Consequently, the residual term, which captures both the underlying changes in total factor productivity plus measurement error terms is never more than 5 per-cent below its level in 1997 and accounts for only one-third of the drop into the trough of 2001 at the height of the crisis.

All of the results above have been computed for the entire sample of plants used to measure the wedges in Section 3. A feature of the data through this period is that there was a large amount of turnover in the plants represented in the survey, with a large number of plants exiting the survey in 2001. The methodology of the survey specifies that a plant should remain in the survey as long as it remains in operation, and so we have interpreted this exit from the survey as exit from production. However, it is plausible that non-response rates increased during the crisis, and that ability of INDEC to monitor non-compliance decreased.

Table : Accounting For The Fall in Argentine Productivity
Continuing Plants

	Change From 1997 (% Chained)				
	1998	1999	2000	2001	2002
Manufacturing Total Factor Productivity (TFP_2)	-1.00	-1.87	-0.48	-9.53	-11.30
Intra Industry Misallocation	-0.77	-0.10	-2.01	-3.04	-5.83
Inter Industry Misallocation	0.36	-0.14	0.30	-0.45	0.10
Residual (Technology and Mismeasurement)	-0.59	-1.63	1.23	-6.04	-5.57

To examine the effect of this exit with a view to both establishing the robustness of our results, and towards an understanding of the role of plant turnover in affecting the efficiency of the allocation of resources, Table 4.D replicates the analysis of Table 4.D for the subset of all plants that responded to the survey in every year form 1997 to 2002. In contrast to the results on the entire sample, the declines in the Solow residual computed using data form the sample of continuing plants are more modest in 1998, and yet more severe in 2001. There is also no increase in the Solow residual between 2001 and 2002.

The effect of intra-industry misallocation is still very large, accounting for more than three-quarters of the initial decline in the Solow residual in 1998, slightly less than one-third of the decline in the height of the crisis, are more than half of the overall decline by 2002. This is consistent with the idea that in the initial years of the crisis, a number of relatively efficient plants exited production, only to be replaced by plants that were either more efficient, or more able to increase efficiency, in 2002 as the economy responded to the crisis. Inter-industry misallocation has more modest effects using the sample of continuing plants, suggesting that the bulk of inter-industry reallocation is accounted for by the exit and entry of new plants. Overall, misallocation accounts for roughly one-third of the decline in TFP to 2001, and half of the decline to 2002.

5   Measuring The Change in Aggregate Welfare

The above Sections explore the extent to which changes in the efficiency of the resource allocation across sectors *accounts for* changes in measured Solow residuals. But how much did these changes matter for welfare? To answer this question we need to be precise about both the timing of the crisis, and the path economy would have taken if no crisis had occurred.

As welfare is a forward looking object, it is necessary to be precise as to the time the crisis became anticipated. We assume that the economy experiences an international financial crisis at time t, which we interpret as an unanticipated change in the prices at which goods trade internationally, the world interest rate, and the entire distribution of wedges faced by firms. To begin, we

think of the crisis as lasting only one period and then extend the framework to consider a persistent crisis below when we take the framework to the data. To measure the effect of the crisis, we need to specify what would have happened in the absence of a crisis. This assumption is especially important: if we assumed that the economy would have remained at a permanently higher income level, the welfare costs of the crisis would be very large. As a response to this concern, we adopt what we consider to be a conservative approach: we assume that in the absence of the crisis at time t, all variables would have remained at their $t - 1$ levels.

In general, the entire equilibrium allocation will be affected by the financial crisis. The change in household welfare as a result of the crisis is given by

$$
\begin{aligned}
dW =\ & U_C\left(C, 1 - L\right) dC + U_L\left(C, 1 - L\right) dL + \Gamma'\left(G\right) dG \\
& + \beta \left(W_K'\left(\left(1 - \delta\right)\left(\hat{K} + I\right), B'\right) dK' + W_B'\left(\left(1 - \delta\right)\left(\hat{K} + I\right), B'\right) dB' \right),
\end{aligned}
$$

where we have dropped the time subscripts and denote future variables with an apostrophe. Substituting for the FOCs of the consumer from (1) and rearranging yields

$$
\frac{dW}{\lambda P_V V} = \frac{P_C C}{P_V V} \frac{dC}{C} - \frac{P_L L}{P_V V} \frac{dL}{L} + \frac{\Gamma'\left(G\right) G}{\lambda P_V V} \frac{dG}{G} + \frac{B'}{P_V V} \frac{dB'}{B'} + \frac{\left(P_I - P_K\right) \hat{K}'}{\left(1 - \delta\right) P_V V} \frac{d\hat{K}'}{\hat{K}'}.
$$

Using the national expenditure identity for real GDP, and denoting the shares of the major national expenditure aggregates by $\omega_C^E, \omega_I^E, \omega_G^E, \omega_X^E$, and ω_M^E, we obtain

$$
\frac{dV}{V} = \omega_C^E \frac{dC}{C} + \omega_I^E \frac{dI}{I} + \omega_G^E \frac{dG}{G} + \omega_X^E \frac{dX}{X} - \omega_M^E \frac{dM}{M}.
$$

Similarly, using the current account identity we obtain

$$
dB' = P_X X \left(\frac{dP_X}{P_X} + \frac{dX}{X}\right) - P_M M \left(\frac{dP_M}{P_M} + \frac{dM}{M}\right) + \left(1 + r_B\right) B \left(\frac{dr_B}{1 + r_B} + \frac{dB}{B}\right),
$$

where we have allowed dB to be non-zero, despite the fact that it is usually thought of as predetermined, to allow for valuation effects on the stock of net foreign assets and for reductions in debt as a result of a default and debt restructuring. Using the former to substitute for the growth rate of

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consumption, and the latter to substitute for the change in net foreign assets yields

$$
\begin{aligned}
\frac{dW}{\lambda P_V V} &= \left(\frac{dV}{V} - \omega_K^V \frac{dI}{K} - \omega_L^V \frac{dL}{L} \right) + \omega_G^E \left(\frac{\Gamma'(G)}{\lambda P_G} - 1 \right) \frac{dG}{G} \\
&\quad + \left(\omega_X^E \frac{dP_X}{P_X} - \omega_M^E \frac{dP_M}{P_M} \right) + \frac{r_B B}{P_V V} \frac{d(r_B B)}{r_B B},
\end{aligned}
\tag{18}
$$

where we have denoted the factor shares of value added by ω_K^V and ω_L^V.

That is, the change in welfare is given by four terms. The first is a measure of TFP growth, defined as the difference between the growth rate of value added and the factor share weighted growth rates of capital and labor. Note that our assumption that households face undistorted market prices is important here, because it enables us to measure the social cost of devoting labor or capital to production from their market prices. In the absence of this assumption, we would need to measure the size of the deviation between the market price of a factor and its social cost.

The second term captures the welfare effects of any changes in government spending. If government spending is valued by the household and the government determines G benevolently, the marginal value of an extra unit of government spending equals its cost, $\Gamma'(G) dG = \lambda P_G$, and this term disappears. If government spending is not valued, then $\Gamma'(G) = \Gamma(G) = 0$ and we should subtract government spending from our measure of gross national income in calculating the the economy's ability to produce income and purchase goods. In what follows we focus on the benevolent government case (although we also present results for the case of purely wasteful government spending).

The third term is an adjustment for changes in the terms of trade; if the price the country receives for its exports rises less than the price it pays for its imports, welfare is reduced. This adjustment differs form the usual terms of trade adjustment used to compute real Gross National Income (referred to as command basis Gross National Product in the US). Although there is no consensus as to the ideal method for computing the terms of trade adjustment (see the debate in Geary 1961 or the range of recommendations given in the United Nations' *System of National Accounts 1993* in paragraphs 16.152 to 16.156; our adjustment was recommended by Rasmusen 1960 and Hamada and Iwata 1984), many countries follow Nicholson (1959) and use an import price index to deflate nominal exports. This alternative approach would yield the expression

$$
\omega_X^E \left(\frac{dP_X}{P_X} - \frac{dP_M}{P_M} \right),
$$

which is equivalent to our adjustment only when trade is balanced. The fourth and final term corresponds to the change in income from net foreign assets, as well as to changes in the net foreign assets position as a result of, for example, a sovereign default[10].

Before applying this framework to the data, it is useful to examine how this framework would be applied to our example economies introduced above.

Example 1 (Continued). *One-Sector Closed Economy Without Frictions*

From equation (17) which relates the Solow residual to growth in technology, we can see that

$$\frac{dTFP_2}{TFP_2} = \frac{dA}{A},$$

which restates the result of Solow (1957). Moreover, as first shown by Weitzman (1976) for the case of linear utility and later shown more generally by Basu and Fernald (2002), our expressions for the change in welfare (18) reduce to

$$\frac{dW}{\lambda P_V V} = \frac{dTFP_1}{TFP_1} = \frac{dA}{A}.$$

Example 2 (Continued). *One-Sector Closed Economy With Imperfect Competition and No Intermediate Inputs*

Relative to the previous example, the only difference is that there is now a wedge between the prices paid by consumers and the marginal cost faced by firms which is given by the mark-up. We represent this in our framework by setting $1 - \tau_{Ki} = 1 - \tau_{Li} = (1 + \tau)^{-1}$ in (17) which yields

$$\frac{dTFP_2}{TFP_2} = \frac{dA}{A} + \tau (1 - \alpha) \left[\frac{dL}{L} - \frac{dK}{K} \right].$$

This can be viewed as a multi-factor analogue of equation (11) in Hall [16]. Likewise for welfare we obtain

$$\frac{dW}{\lambda P_V V} = \frac{dTFP_1}{TFP_1} + \tau \frac{dK}{K} = \frac{dA}{A} + \tau \left[\alpha \frac{dK}{K} + (1 - \alpha) \frac{dL}{L} \right]$$

which is the analogue of equations (14) and (28) in Basu and Fernald [5] (with only one sector, the sectoral-reallocation terms are set to zero).

Example 3 (Continued). *One-Sector Open Economy Without Frictions*

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[10]It is possible to derive an equivalent expression with TFP measured using gross national income (GNI) growth, subtracting factor growth weighted by shares in GNI.

Next we consider a one-sector open economy without frictions and with unbalanced trade. As for the closed economy version studied above, the relative prices of investment, consumption and output are all fixed at one, and so are the prices of exports and imports. Substituting this into our formulae we obtain

$$\frac{dW}{\lambda P_V V} = \frac{dTFP_1}{TFP_1} + \frac{r_B B}{P_V V} \frac{dr_B}{r_B} = \frac{dA}{A} + \frac{r_B B}{P_V V} \frac{dr_B}{r_B}.$$

Example 4 (Continued). *Small Open Economy with Imported Intermediate Inputs*

Under the assumptions that K and L are fixed, (17) reduces to

$$\frac{dTFP_2}{TFP_2} = 0,$$

which is Kehoe and Ruhl's main point: if output is measured ideally, changes in the terms of trade will have no effect on the measured Solow residual. Below we will argue that output is typically not measured ideally (that is, it is not measured using double deflation), and instead is often measured using what is known as single deflation, for which case we obtain

$$\frac{dTFP_2}{TFP_2} = -\frac{P_M M}{P_V V} \frac{dP_M}{P_M}.$$

This shows that movements in the terms of trade can impact measured Solow residuals, which serves as a counterpoint to the argument in Bajona, Kehoe and Ruhl (2008).

As regards welfare, our equation (18) reduces to

$$\frac{dW}{\lambda P_V V} = \frac{Y}{Y - P_M M} \frac{dY}{Y} - \frac{P_M M}{Y - P_M M} \left(\frac{dP_M}{P_M} + \frac{dM}{M} \right).$$

In the special case where output is Leontieff in primary factors and imported intermediates (here $Q = M$), we know $dY/Y = dM/M$. Moreover, since primary factors are constant, if we assume that there is no change in technology $dY/Y = 0$. Then we have

$$\frac{dW}{\lambda P_V V} = -\frac{P_M M}{P_V V} \frac{dP_M}{P_M}.$$

That is, if the price of imports rises (the terms of trade worsen), welfare falls by an amount proportional to the share of imports in gross domestic product. Interestingly, in this case, measuring the Solow residual from output incorrectly constructed using single deflation leads to a correct estimate of the change in welfare.

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Example 5 (Continued). *Two-Sector Open Economy Without Frictions*

In this case, we obtain

$$\frac{dTFP_2}{TFP_2} = \frac{dA}{A},$$

while

$$\frac{dW}{\lambda P_V V} = \frac{dA}{A} + \frac{P_X X}{P_V V}\frac{dP_X}{P_X} - \frac{P_M M}{P_V V}\frac{dP_M}{P_M} + \frac{r_B B}{P_V V}\frac{dr_B}{r_B}.$$

5.A Multi-Period Crises

In the analysis above, we assumed that the crisis was a surprise when it occurred, and lasted for only one period. In many applications, crises are anticipated in advance of their occurrence and last for multiple periods. As shown in the timeline above, for example, the Argentine crisis was being forecast as early as April 1998 when IMF officials warned of a possible "meltdown", and continued at least through the first half of 2002. This has no effect on our analysis of the Solow residual above given the assumptions of our model. However, as consumers are forward looking, it will have an impact on the change in welfare. In particular, when we calculate the change in household welfare, we must now take into account the change in tomorrows value function, as well as the change in its value resulting from different accumulation decisions.

Under our assumption that the economy would have remained in its pre-crisis state in the-duration of the crisis, the welfare effects of multiperiod crises are straightforward to analyze[11]. Replicating the derivations above we find that the change in welfare now includes another term capturing the change in future welfare

$$\begin{aligned}
\frac{dW}{\lambda P_V V} &\equiv \frac{\partial W/\partial t}{\lambda P_V V} = \frac{dTFP_1}{TFP_1} + \omega_G^E\left(\frac{\Gamma'(G)}{\lambda P_G} - 1\right)\frac{dG}{G} \\
&+ \left(\omega_X^E\frac{dP_X}{P_X} - \omega_M^E\frac{dP_M}{P_M}\right) + \frac{r_B B}{P_V V}\frac{d(r_B B)}{r_B B} + \frac{1}{1+r_B'}\frac{P_V'V'}{P_V V}\frac{\partial W'/\partial t}{\lambda'P_V'V'}.
\end{aligned}$$

Hence, writing the growth rate of nominal value added as the product of the rate of inflation π' and the rate of growth of real GDP g' we obtain

$$\frac{1}{1+r_B'}\frac{P_V'V'}{P_V V} = \frac{1+g'}{1+R_B'},$$

---

[11]Without this assumption, we would need to specify the path of all variables in the absence of a crisis and measure changes relative to this path.

where

$$1 + R'_B = \frac{1 + r'_B}{1 + \pi'}.$$

That is, we can simply iterate on this analysis and accumulate using a growth adjusted real interest rate.

5.B   Results

Table 8.E collects our measurements on the components of the change in welfare as a result of the crisis. Each element of the table refers to the flow contribution of each component for that year relative to its level in 1997. As above, we compute these changes using the Tornqvist approximation to the Divisia Index. For the reasons discussed above we use the sample of continuing plants to compute the aggregate Solow residual (the appendix contains the same Table using data from all plants).

Table : The Change in Welfare and its Components against 1997

Continuing Plants

Year		1998	1999	2000	2001	2002
Solow Residual		−1.00	−1.87	−0.48	−9.53	−11.30
Mismeasured Factor Elasticities		0.25	0.45	0.57	0.58	0.65
Foreign Trade	Goods	−0.43	−0.87	−0.04	−0.15	10.04
	Factors	−0.43	−0.45	−0.47	−0.55	−2.50
Government:	Consumption	−0.42	−0.83	−0.92	−0.63	0.10
	Consumption & Investment	−0.46	−0.84	−0.32	0.01	0.90
Flow Welfare	Benevolent	−1.60	−2.75	−0.43	−9.65	−3.11
	Wasteful G	−2.02	−3.58	−1.35	−10.29	−3.01
	Wasteful $G + I$	−2.07	−3.59	−0.75	−9.64	−2.21

To obtain the appropriate measurement for welfare purposes we need to correct the Solow residual for the mismeasurement of the capital share of output. Doing so results in slightly smaller declines in productivity growth as shown in the second row of the Table.[12]

The third line in the Table captures the contribution of changes in export and import prices on welfare. For most years this is quite modest reflecting the fact that, early in the crisis, Argentine

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[12]We estimate the mismeasurement using aggregate data on the evolution of the stock of capital and returns to capital from INDEC.
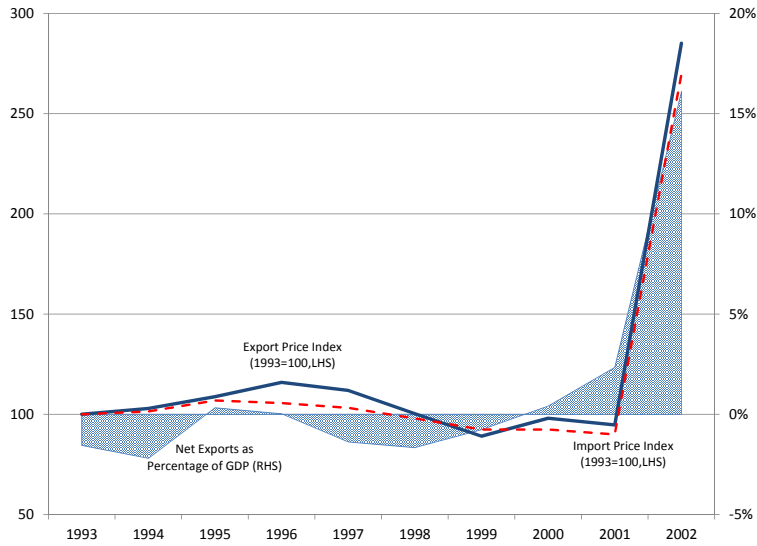
Figure 6: The Prices of Exports and Imports

trade was close to balanced. The exception is the year 2002, where changes in tradeable goods prices produced a 10 per-cent positive contribution to welfare. The reason is that, as shown in Figure 6, in 2000 Argentina had transitioned from a net importer to a net exporter. Moreover, as a result of the depreciation in the Argentine peso, both export and import prices in pesos roughly tripled in one year. As Argentina was a net exporter (and by 2002, a substantial net exporter) the higher prices in pesos received for its exports more than offset the higher prices paid for imports resulting in a substantial increase in welfare.

The fourth line in the Table captures the contribution from changes in income derived from Argentina's foreign investment position. The numbers are negative each year reflecting the fact that Argentina is a net debtor and that the income owed on these debts was increasing each year. The increase is especially large in 2002; despite the write-down in the country's foreign debts, the depreciation of the peso resulted in a large increase in income paid to foreigners which contributed a 2.5 per-cent reduction in welfare that year.

It is important to stress that this result uses current account data measured on a cash-flow basis, which includes the reduction in foreign interest payments as a result of the sovereign default. This does not, however, capture the effect of expected reductions in future debt service as a result of the sovereign default at the end of 2001. The appendix discusses a number of measurement issues associated with these data, and describes an alternative that aims to capture the reduction in the value of Argentina's foreign debt resulting from the default. With this adjustment, the default makes a positive 0.4% contribution to welfare in 2002.

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If we assume that the government of Argentina is benevolent and sets its expenditure at the point where its marginal social cost equals its marginal social benefit, then we find that the flow effect on welfare is driven predominantly by movements in total factor productivity in every year from 1998 to 2001. Negative contributions from foreign trade in goods and factors rarely exceed five per-cent of the contribution from productivity. The resulting changes in flow welfare vary from -3.5 to -11.5 per-cent of one years GDP. In 2002, by contrast, the large positive contribution from traded goods prices more than offsets the negative contribution from productivity and all other factors, resulting in an increase in flow welfare of 2.3 per-cent of that years GDP.

To compute the total effect on welfare of the crisis, we need to cumulate the discounted flow changes in welfare. To do so, we use a discount rate of 5 per-cent per year, and assume that the crisis ends in 2003 with all real variables returning to the level they would have been had no crisis occurred. We view the latter as conservative; if the crisis had permanent effects the change in welfare would be much larger. Cumulating welfare flows in this way we find that the crisis reduced Argentine welfare by an amount equivalent to a 24.6 per-cent reduction in 1998 GDP. Adjusting the contribution from net foreign income to account for the sovereign default, this number rises to -22.3% of 1998 GDP.

If we assume that the government of Argentina is not benevolent, or for some other reason (perhaps due to political economy problems or through the use of distortionary taxation) is unable to equate the social costs and benefits of its spending, we need to take a stand on how far away from the optimum this spending is. As a more or less natural benchmark, we focus on the case in which government spending is purely wasteful. As shown in lines five and six of the Table, depending on whether or not government investment is also considered wasteful, the contribution to welfare from the direct spending of the government is typically on the order of one-half to one per-cent of GDP, negative in periods where government spending rose, and positive when it declined.

Computing the change in welfare as a result of changes in government spending, we find that the welfare numbers are similar to the case with an optimal government. This reflects the fact that the changes in government spending were quite small, and that the government is only a modest component of the overall Argentine economy. Cumulating these discounted welfare flows, we find that the decline in welfare is slightly larger at an amount equivalent to 27 per-cent of 1998 GDP, using only government consumption, falling back to 25.4 per-cent if government investment is included. The reason is that the increases in government spending in the early years of the crisis offset the large fall in government spending in 2002 as the borrowing constraints on the government

tightened.

It is, of course, important to be cautious in interpreting these welfare change numbers. Most importantly, our estimates have been designed to be conservative. For one thing, the fact that the sovereign default has still not been fully resolved as of this writing, and access to international capital markets remains limited, suggest that the declines in welfare might extend beyond 2002. At the same time, our assumption of a representative agent means that we do not account for the heterogeneous impact of the crisis on different Argentine citizens. Finally, our model has nothing to say about the effects of involuntary unemployment on welfare.

6 Conclusions

Financial crises in emerging market economies appear to be very costly. In this paper, we presented a theoretically consistent methodology for calculating the welfare costs of a crisis (or any economic shock) on a small open economy and for decomposing these welfare costs into the effect of changes in the terms of trade, the terms of foreign investments, changes in government spending, and changes in an economies productive capacity. We use the framework also to measure the impact of changes in the efficiency of the resource allocation mechanism in productive capacity.

We then applied this methodology to Argentina for the 2001 – 2002 financial crisis using a mixture of aggregate data, and plant level data drawn from a unique dataset. Using conservative assumptions, we found that welfare fell by an amount equivalent to roughly a 25 per-cent in GDP as a result of the crisis. The largest amount of this decline is due to declines in the measured productivity of the Argentine economy, although substantial offsetting improvements in tradeable goods prices, and potentially also tighter constraints on government spending, were also significant. Using micro data on manufacturing plants, we show that, of the decline in productivity, more than half can be explained by a decline in the efficiency of the resource allocation mechanism which shows up with an increasingly poor allocation of factors across plants as the crisis progresses.

Our framework can applied in a number of areas. Focusing on the measurement of welfare changes, an advantage of our framework is that it provides a single theoretically consistent measure of welfare change that is related to, but distinct from, measures currently in use for measuring real national income and total factor productivity. Thus, it allows researchers to replace the patchwork collection of facts that usually passes for a quantification of the social costs of crises. Applying this measure to a wide range of crises also holds out the promise of being able to identify the types of crises, and their features, that are most important in affecting welfare. For example, we may be

able to ascertain whether sovereign defaults are, on average, more costly that currency crises, and whether this works primarily through changes in the terms of trade, or changes in the ability of the economy to produce output.

To the extent that changes in the efficiency of the resource allocation mechanism prove to be the most important channel, this begs the question of the precise mechanism by which a crisis affects the allocation. It seems plausible that financial crises, which often result in severe disruption of the domestic financial sector, would lead to a decline in the efficiency with which financial intermediation occurs. It also seems plausible that, to the extent to which credit mechanisms are important in facilitating exchange, a decline in the efficiency of financial intermediate may lead to a deterioration in the operation of labor markets (through the availability of working capital, as in Neumeyer and Perri 2004) or intermediate input markets (as in Mendoza and Yue 2008). In future work, we plan to study the details of the evolution of the wedges computed above with a view to discriminating between these different mechanisms.

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7   Efficient Industry Productivity

In the text, we define the industry j productivity level, A_j, as the level that would arise if all factor input wedge were zero so that factors were efficiently allocated across plants. In this appendix, we elaborate on the process of defining A_j and discuss one alternative definition.

7.A   Efficient Allocation Given N

Recall that our measure of misallocation within an industry, Φ, (suppressing the industry subscript) is defined as

$$
\Phi = \sum_i \pi_i \left\{ (1 - \tau_{Ai}) \left(\frac{(1 - \tau_{Ki})(1 - \tau_i)}{\sum_i \pi_i (1 - \tau_{Ki})(1 - \tau_i)} \right)^{\alpha\gamma} \left(\frac{(1 - \tau_{Li})(1 - \tau_i)}{\sum_i \pi_i (1 - \tau_{Li})(1 - \tau_i)} \right)^{\beta\gamma} \times \right.
$$
$$
\left. \left(\frac{(1 - \tau_{Qi})(1 - \tau_i)}{\sum_i \pi_i (1 - \tau_{Qi})(1 - \tau_i)} \right)^{(1-\alpha-\beta)\gamma} \right\}.
$$

Intuitively, we desire a measure of that reaches a maximum if and only if all factor wedges are zero (so that there is no misallocation of factors). We set industry productivity level A to normalize this maximum value of Φ to one. That is, we define industry productivity so that when all wedges *except* for the τ_{Ai} are zero, $\Phi = 1$.

If we set all factor wedges to zero, then for any definition of industry productivity (which implies a given set of efficiency wedges τ_{Ai}), we have

$$
A\Phi = \sum_i \pi_i A_i \left(\frac{(1 - \tau_{Ai})^{1/(1-\gamma)}}{\sum_i \pi_i (1 - \tau_{Ai})^{1/(1-\gamma)}} \right)^{\gamma}
$$
$$
= \sum_i \pi_i A_i \left(\frac{A_i^{1/(1-\gamma)}}{\sum_i \pi_i A_i^{1/(1-\gamma)}} \right)^{\gamma}.
$$

Hence, we define A as

$$
A = \sum_i \pi_i A_i \left(\frac{A_i^{1/(1-\gamma)}}{\sum_i \pi_i A_i^{1/(1-\gamma)}} \right)^{\gamma},
$$

which generates the desired result.

To interpret this definition, note that from our earlier computations we have

$$
\frac{P_Y Y_i}{P_Y Y} = \frac{Y_i}{Y} = \frac{(1 - \tau_{Ai})^{1/(1-\gamma)} \left[(1 - \tau_{KSi})^{\alpha} (1 - \tau_{Li})^{\beta} (1 - \tau_{Qi})^{1-\alpha-\beta} \right]^{\gamma/(1-\gamma)}}{N \sum_i \pi_i (1 - \tau_{Ai})^{1/(1-\gamma)} \left[(1 - \tau_{KSi})^{\alpha} (1 - \tau_{Li})^{\beta} (1 - \tau_{Qi})^{1-\alpha-\beta} \right]^{\gamma/(1-\gamma)}}
$$
$$
= \frac{A_i^{1/(1-\gamma)}}{N \sum_i \pi_i A_i^{1/(1-\gamma)}},
$$

41

when we zero out the distortions, so that

$$A = \sum_i \pi_i A_i \left(\frac{Y_i}{Y/N} \right)^\gamma.$$

That is, instead of taking the arithmetic average $\sum_i \pi_i A_i$, we distort the average by multiplying by

$$\left(\frac{Y_i}{Y/N} \right)^\gamma$$

which is the ratio of firm size to average firm size raised to γ. This is not a weighted average, because although

$$\sum_i \pi_i \left(\frac{Y_i}{Y/N} \right) = 1,$$

when raised to the power γ these terms will not sum to one.

We can establish a few properties of this measure. For example, it is straightforward to show that if all plants in industry j have the same productivity level $A_i = A$ for all i, then $A_j = A$. Likewise, the fact that $f(x) = x^\gamma$ is concave for $\gamma \in (0,1)$ and that the A_i are non-negative implies that our measure of industry productivity is greater than the arithmetic average productivity level of plants.

Lemma 1. *Let* $\bar{A} = \sum_i \pi_i A_i$. *Then* $A^1 \geq \bar{A}$.

Proof. Suppressing the industry subscript, note that

$$
\begin{aligned}
A &= \sum_i \pi_i A_i \left(\frac{Y_i}{Y/N} \right)^\gamma \\
&= \bar{A} \sum_i \frac{\pi_i A_i}{\bar{A}} \left(\frac{Y_i}{\overline{Y}} \right)^\gamma \\
&\geq \bar{A} \left(\sum_i \frac{\pi_i A_i}{\bar{A}} \frac{Y_i}{\overline{Y}} \right)^\gamma \\
&\geq \bar{A} \left(\sum_i \pi_i \frac{Y_i}{\overline{Y}} \right)^\gamma \\
&= \bar{A},
\end{aligned}
$$

where the first inequality follows from the fact that the $\pi_i A_i / \bar{A}$ are non-negative and sum to one, and hence constitute a probability measure so that we can apply Jensen's inequality. The second inequality follows from the fact that $A_i / \bar{A}$ is positively correlated with $Y_i / \overline{Y}$. The third line follows from the definition of $\overline{Y}$. $\qquad\square$

Finally, note that if we fix the number of plants and the total supply of factors to an industry, the allocation of resources across establishment types generated by the market maximizes aggregate TFP.

Lemma 2. *Given the total number of establishments N, the total supply of factors to an industry K, L, Q, and in the absence of factor distortions, the allocation of resources across establishment types generated by the market maximizes aggregate TFP.*

Proof. The allocation that maximizes TFP, given factor inputs to the industry is the allocation that maximizes output (as N is fixed, we do not need to distinguish between capital used by plant and total capital). This solves

$$\max_{K_i, L_i, Q_i} \sum_i \pi_i A_i \left(K_i^\alpha L_i^\beta Q_i^{1-\alpha-\beta} \right)^\gamma N,$$

subject to

$$\sum_i \pi_i K_i N \leq K,$$

$$\sum_i \pi_i L_i N \leq L,$$

$$\sum_i \pi_i Q_i N \leq Q.$$

Letting $\lambda's$ denote the multipliers, the FONSC are

$$\alpha\gamma \frac{Y_i}{K_i} = \lambda_K,$$

$$\beta\gamma \frac{Y_i}{L_i} = \lambda_L,$$

$$(1 - \alpha - \beta)\gamma \frac{Y_i}{Q_i} = \lambda_Q,$$

which along with the constraints serves to pin down the optimum. But these are the same equations as the ones that solve for the competitive equilibrium allocation derived in the text (given factor supplies) with $\lambda_K = P_K/P_Y$ etc. $\qquad\square$

The above result, which characterizes optimal allocations within an industry given the total number of establishments and given an aggregate allocation across industries, is a necessary condition for an optimal allocation overall although it is not sufficient because N and the factor allocation may not be optimal. Next we study what happens if we endogenize N.

7.B Endogenizing N

When N is allowed to vary, we showed in the text that

$$Y = \left(A\Phi\Lambda^{1-\gamma} \right)^{1/\gamma} K^\alpha L^\beta Q^{1-\alpha-\beta}.$$

We want to compute the difference between $\left(A\Phi\Lambda^{1-\gamma} \right)^{1/\gamma}$ as measured from the data, and the level it would attain without factor distortions. In the previous subsections, constructed A such that

$A\Phi = A$ without distortions. As regards Λ, in the absence of distortions

$$\Lambda = \frac{1-\gamma}{P_K F / P_Y}.$$

This suggests that an alternative definition of industry productivity would be

$$A^2 = \left(A^1 \left(\frac{1-\gamma}{P_K F / P_Y} \right)^{1-\gamma} \right)^{1/\gamma},$$

where A^1 denotes the measure introduced in the previous subsection. Then we would define

$$\Phi^2 = \frac{\left(A^1 \Phi^1 \Lambda^{1-\gamma} \right)^{1/\gamma}}{A^2},$$

so that Φ^2 captures differences from optimal A in a Solow accounting exercise on industry data.

We do not follow this approach in the paper because we view it as less intuitive that the approach of the previous subsection. In particular, note that if all wedges were zero so that $A_i = A$ for all i, then

$$A^2 = \left(A \left(\frac{1-\gamma}{P_K F / P_Y} \right)^{1-\gamma} \right)^{1/\gamma},$$

and the measure does not move one-for-one with firm productivity.

Nonetheless, this alternative definition of industry productivity is optimal in the sense used in the previous subsection.

Lemma 3. *Given the total supply of factors to an industry and in the absence of factor distortions, the allocation of resources across establishment types generated by the market maximizes aggregate TFP.*

Proof. The allocation that maximizes TFP, given factor inputs to the industry is the allocation that maximizes output. This solves

$$\max_{K_i, L_i, Q_i, N} \sum_i \pi_i A_i \left(K_i^\alpha L_i^\beta Q_i^{1-\alpha-\beta} \right)^\gamma N,$$

subject to

$$\sum_i \pi_i \left(K_i + F \right) N \ \leq \ K,$$

$$\sum_i \pi_i L_i N \ \leq \ L,$$

$$\sum_i \pi_i Q_i N \ \leq \ Q.$$

Letting $\lambda's$ denote the multipliers, the FONSC are

$$\alpha\gamma\frac{Y_i}{K_i} = \lambda_K,$$
$$\beta\gamma\frac{Y_i}{L_i} = \lambda_L,$$
$$(1-\alpha-\beta)\gamma\frac{Y_i}{Q_i} = \lambda_Q,$$

while the FOC in N is

$$\sum_i \pi_i A_i \left(K_i^\alpha L_i^\beta Q_i^{1-\alpha-\beta}\right)^\gamma - \lambda_K \sum_i \pi_i (K_i + F) - \lambda_L \sum_i \pi_i L_i - \lambda_Q \sum_i \pi_i Q_i = 0.$$

Along with the constraints, these conditions serve to pin down the optimum. But these are the same equations as the ones that solve for the competitive equilibrium allocation (given factor supplies) with $\lambda_K = P_K/P_Y$ etc. This is as before, but for the FOC in N, which after substituting from the other FOCs and rearranging can be seen to be equivalent to the free entry condition for establishments

$$(1-\gamma)\sum_i \pi_i P_Y Y_i = P_K F.$$

$\square$

8 Establishment Data Appendix

8.A Further Details of Dataset

This appendix provides more data on the establishment level data used in the text. The first Table reports data from the 1994 National Economic Census of manufacturing establishments. It estabishes the claim in the text that, although the small (less than 10 employees) establishments which are excluded from our dataset are numerous, accounting for 84% of the total number of establishments in the economy, they account for only 22% of total employment.

Number of plants and employment by size class, 1993								
plant size	Number of plants				Employment			
(#N)	Numb plants	Cumul total	Share	Cumul share	Empl	Cumul total	Share	Cumul share
1	26,312	26,312	28	28	26,505	26,505	2	2
2-3	27,738	54,049	30	58	67,385	93,889	6	9
4-5	12,480	66,529	13	71	56,050	149,940	5	14
6-10	11,330	77,859	12	84	87,410	237,350	8	22
11-25	8,711	86,570	9	93	141,984	379,334	13	36
26-40	2,418	88,988	3	96	78,236	457,569	7	43
41-50	880	89,868	1	96	40,589	498,159	4	47
51-150	2,348	92,216	3	99	199,975	698,134	19	66
151-250	441	92,657	0	99	87,123	785,256	8	74
251-400	280	92,937	0	100	89,369	874,625	8	82
401+	219	93,156	0	100	186,903	1,062,528	18	100

Source: 1994 INDEC's National Economic Census (last available economic census)

The data provided to us by INDEC includes an establishment identifier which allows us to track the performance of each establishment over time. The survey provides information on a range of plant characteristics including the year in which activities began, whether it is the only plant of the plant, foreign ownership (share of foreign capital equal to 0%, between 0% and 10%, more than 10%), and subsector (there are 22 subsectors shown in the Table below). The operational data provided by INDEC includes total wages, total hours worked, cost of inputs, interest payments, expenditures in electricity, gas and other energy sources, total expenditures, total sales in domestic and foreign markets (if any) and investment for each establishment. No balance sheet data are collected, and so we do not have a direct estimate of the plants' capital stock.

8.B   Estimation of Employment Levels for Aggregation Purposes

As noted in the text, we use data on the growth rate of employment along with size bin identifiers to estimate the level of employment at each plant at any point in time. The Figure compares the aggregate series for gross output taken from the INDEC survey, to that constructed from our data using our estimated employment sizes. As shown in the Figure, the two series move together quite closely, with the only qualitative difference occurring in 1998 when the INDEC series increases, while the estimated series declines slightly.

Industries	
15	Food Products and Beverage
16	Tobacco Products
17	Textile Products
18	Clothing Products
19	Leather Products
20	Wood and Cork Products (exc. Furnitures)
21	Pulp and Paper
22	Printing, Editing and Recording Activities
23	Petroleum and Coke (fuel) Products
24	Chemicals Products
25	Rubber and Plastics Products
26	Non-metallic Mineral Products
27	Basic Metals
28	Fabricated Metal Products (exc. Machinery)
29	Mechanical Machinery and Equipment
30	Office Machinery
31	Electrical Machinery and Components
32	Radio, TV and Communication devices
33	Medical, Optical and Precision Instruments.
34	Motor Vehicles and Trailers
35	Other tipe of Transportation Vehicles
36	Furnitures

Figure 7: INDEC Manufacturing Industry Classifications

8.C Scatter Plots Illustrating Correlations Between Wedges

Figures 9 through 11 present scatter plots of the log of the wedges against the log of productivity for the years 1997 and 2002. The figures confirm the patterns described by the statistics in Table 1 in the text.

8.D Tornqvist vs Fisher Ideal Index

In the text, when examining the growth rate of welfare and output we took derivatives with respect to time. The formulae that results therefore correspond to growth rates of Divisia Indices. As our data is measured at discrete intervals, it is necessary to approximate the growth rates of these Divisia Indices with a discrete index. There are many different approximations that may be used. In the text we focus on the Tornqvist Index, but also Fisher Ideal Index could be used.
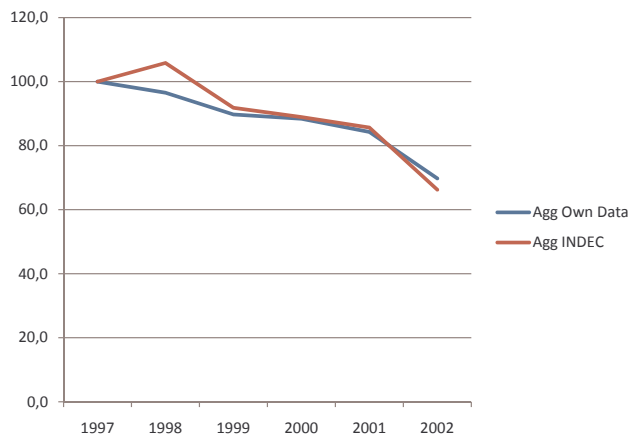

Figure 8: INDEC and Author Estimates of Manufacturing Gross Output
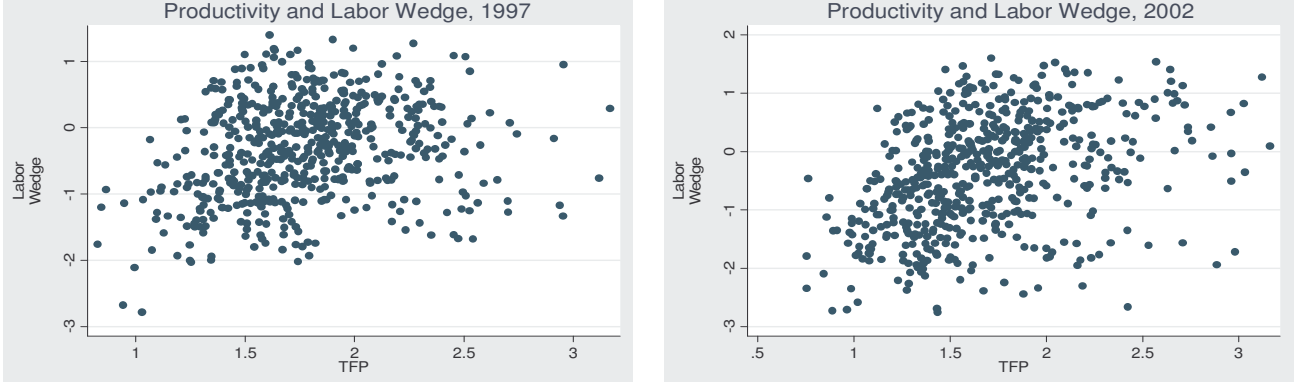
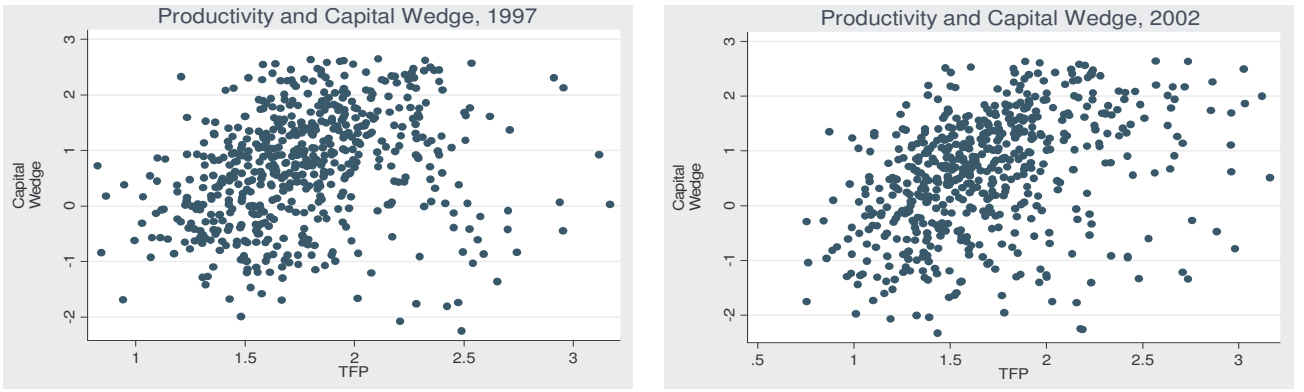Figure 9: Relationship Between Labor & Productivity Wedges in 1997 & 2002

Figure 10: Relationship Between Capital & Productivity Wedges in 1997 & 2002

Using our measure of aggregate intra-industry resource misallocation as an example, we approximate the Divisia index with the Tornqvist Index using

$$\sum_j \omega_{Yt}^j \frac{1}{\gamma_j} \frac{d\Phi_{jt}}{\Phi_{jt}} \approx \sum_j \bar{\omega}_{Yt,t+1}^j \frac{1}{\gamma_j} \ln\left(\frac{\Phi_{jt+1}}{\Phi_{jt}}\right),$$

where

$$\bar{\omega}_{Yt,t+1}^j = \frac{1}{2}\left(\omega_{Yt}^j + \omega_{Yt+1}^j\right).$$

Alternatively, we could approximate using a Fisher Ideal Index, constructing

$$1 + g_{1t,t+1} = \sum_j \omega_{Yt}^j \frac{1}{\gamma_j} \frac{\Phi_{jt+1}}{\Phi_{jt}},$$

$$1 + g_{2t,t+1} = \sum_j \omega_{Yt+1}^j \frac{1}{\gamma_j} \frac{\Phi_{jt+1}}{\Phi_{jt}},$$
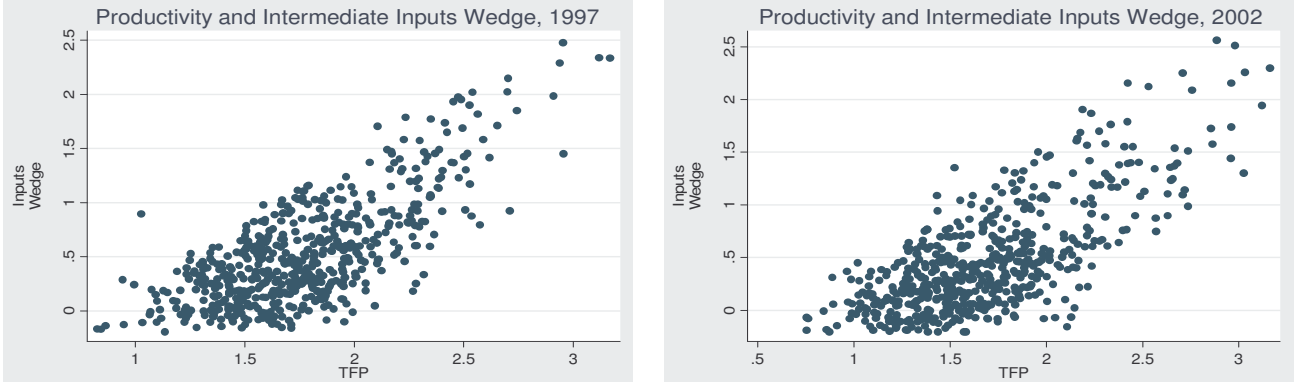
Figure 11: Relationship Between Intermediate Input & Productivity Wedges in 1997 & 2002

and then find the growth rate as

$$g^*_{t,t+1} = \sqrt{(1 + g_{1t,t+1})(1 + g_{2t,t+1})} - 1.$$

We also use a Tornqvist index when computing changes in welfare. For the year 2002, this presents a problem when the contribution of net foreign income changes sign. For that year, we approximate the log-difference with a percentage change.

8.E   Welfare Analysis Using Data on All Establishments

In the text, we present our welfare analysis using data on surviving establishments. Here we present the results using data on all firms.

Table : The Change in Welfare and its Components against 1997
All Firms

Year		1998	1999	2000	2001	2002
Solow Residual		−7.45	−6.06	−3.45	−11.45	−5.88
Mismeasured Factor Elasticities		0.25	0.45	0.57	0.58	0.65
Foreign Trade	Goods	−0.43	−0.87	−0.04	−0.15	10.04
	Factors	−0.43	−0.45	−0.47	−0.55	−2.50
Government:	Consumption	−0.42	−0.83	−0.92	−0.63	0.10
	Consumption & Investment	−0.46	−0.84	−0.32	0.01	0.90
Flow Welfare	Benevolent $G + I$	−8.05	−6.94	−3.40	−11.57	2.31
	Wasteful G	−8.47	−7.77	−4.32	−12.20	2.41
	Wasteful $G + I$	−8.52	−7.77	−3.72	−11.56	3.21

9 Aggregate Data Appendix

9.A Single vs Double Deflation

As noted in the text, a potentially serious problem with the measurement of aggregate value added in Argentina is the widespread use of single deflation. To understand the nature of this error, note that in the theory above, movements in real GDP were constructed from the production side of the national accounts using equation (15) by taking the growth rate of the value of output, measured in base year prices, and subtracting from this the value of intermediate input growth, also valued at base year prices. In the terminology used by national income statisticians, real value added was constructed using *double deflation* which refers to the fact that prices for *both* output *and* intermediate inputs were held constant. With the addition of energy as an input, this now requires subtracting growth in energy usage valued at base year prices.

As a practical matter, data on prices are both expensive to collect and subject to serious measurement error. This problem is especially severe for developing countries. In such cases the United Nations' System of National Accounts recommends several alternative methods for calculating real value added[13]. One of the most commonly used involves deflating nominal value added by the output price and is hence referred to as *single deflation* in which case real value added is given by

$$V_s^{SD} = P_{Yt}\left(Y_s - \frac{P_{Qs}}{P_{Ys}}Q_s - \frac{P_{Es}}{P_{Ys}}E_s\right) = \sum_m P_{Ymt}\left(Y_{ms} - \frac{P_{Qs}}{P_{Yms}}Q_{ms} - \frac{P_{Es}}{P_{Yms}}E_{ms}\right).$$

In the case of Argentina, the primary measure of real gross domestic product is constructed from the production side of the accounts, with real value added by industry constructed using different methods for each industry depending on the data available[14] We estimate that approximately one-quarter of Argentine value added is constructed using single deflation. To see the size of the potential measurement error this induces, we approximate this complicated state of affairs by treating gross domestic product data as though it was constructed using single deflation for a subcomponent of the economy denoted SD. In continuous time in the neighborhood of the base year (and hence ignoring the importance of rebasing), the relationship between Divisia real value added growth, calculated using double deflation (denoted V), and that measured using a mixture of single and double deflation (denoted V^M for "measured"), satisfies

$$\frac{dV^M}{V^M} = \frac{dV}{V} - \frac{P_{VSD}V^{SD}}{P_V V}\left[\frac{P_Q Q^{SD}}{P_{VSD}V^{SD}}\left(\frac{dP_Q}{P_Q} - \frac{dP_{YSD}}{P_{YSD}}\right) + \frac{P_E E^{SD}}{P_V V}\left(\frac{dP_E}{P_E} - \frac{dP_{YSD}}{P_{YSD}}\right)\right],$$

where we have exploited the fact that in the base year $P_V V = P_{VM}V^M$. This shows that if intermediate input prices rise at the same rate as output prices, the two measures are equivalent, while if they rise faster the growth rate of real value added will be understated. As shown in Figure 12, the relative price of intermediate inputs to output rose substantially for Argentina during this period.

9.B Balance of Payments Data

As derived above, changes in the flow of net foreign income have a direct effect on the welfare of the representative consumer in this economy: a decrease in the income paid to foreigners increases

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[13]See paragraphs 16.68 to 16.70 of the United Nations System of National Accounts 1993 available at http://unstats.un.org/unsd/sna1993/toctop.asp.

[14]See http://www.mecon.gov.ar/secpro/dir_cn/ant/fuentes/mi.htm for details.
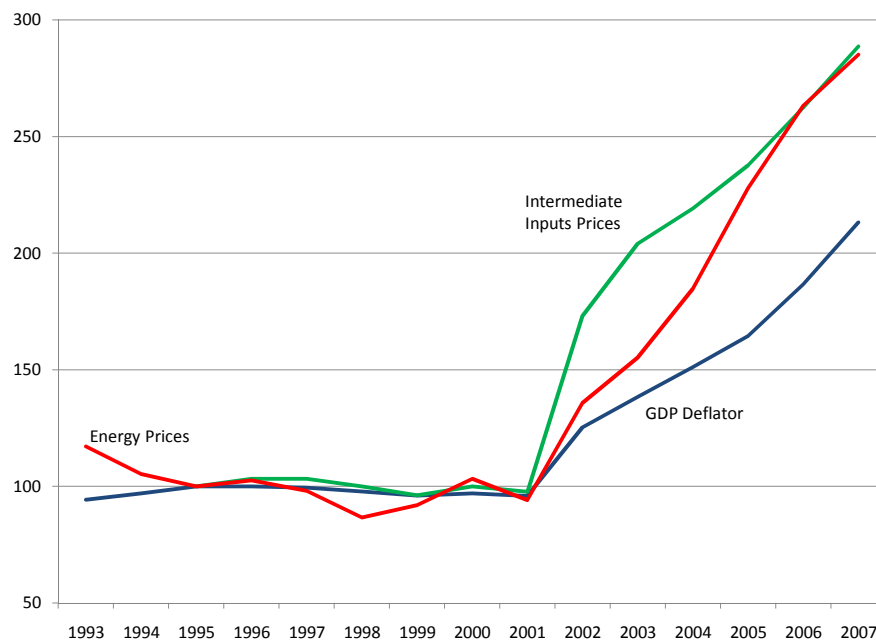
Figure 12: Relative Prices of Intermediate Inputs

domestic welfare. We use data from the Argentine balance of payments to estimate these changes. Before doing so, however, we need to confront a number of important measurement issues.

As for most other countries, and as recommended by the International Monetary Fund (2004), the Argentine balance of payments is constructed on an "accrual basis". On accrual basis, Argentina's default has no effect on the current account: the payments that were not made as a result of the default are treated as though they were made, and were funded by an offsetting new loan. As a consequence, it is necessary to modify the measure of net factor income from the balance of payments for use in calculating welfare changes. We consider two such adjustments.

The first adjustment we consider is to subtract those payments that were not made as a result of the default. This can be measured from the size of the offsetting loan that appears in the capital account. We refer to this adjusted net factor income series as being measured on a "cash basis". However, this measure is also problematic in that it makes no allowance for the expected reduction in future net foreign income paid abroad as a result of the sovereign default.

The second adjustment is designed to capture this effect, and reflects the fact that, by definition, the current account is intended to capture the change in a country's stock of net foreign assets. In practice, a country's stock of net foreign assets can change as the result of transactions, valuation effects reflecting exchange rate movements and capital gains and losses, and as the result of other adjustments such as defaults and nationalizations. The balance of payments, however, was traditionally designed to capture only those changes due to transactions (see IMF 2004 p.6). It is this traditional conception of the balance of payments that is used by Argentina.

Argentina does provide estimates of its net international investment position at market prices. However, these estimates are notoriously difficult to construct given that they involve finding market prices for many assets that are not traded in liquid markets, and that the identification of assets that are foreign owned is often difficult. This is particularly problematic in the case of a sovereign default, where many foreign bonds are held by domestic agents, and many domestic bonds are held by foreign agents.

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Our second corrected measure of net foreign income uses the reported reduction in liabilities of the public sector from the International Investment Accounts as an estimate of the effect of the default on Argentina's net foreign asset position. All three measures are plotted in Figure 13. As shown, when market values are used, the behavior of net foreign income is both qualitatively and quantitatively different. It is these differences that explain the different results obtained in the text.
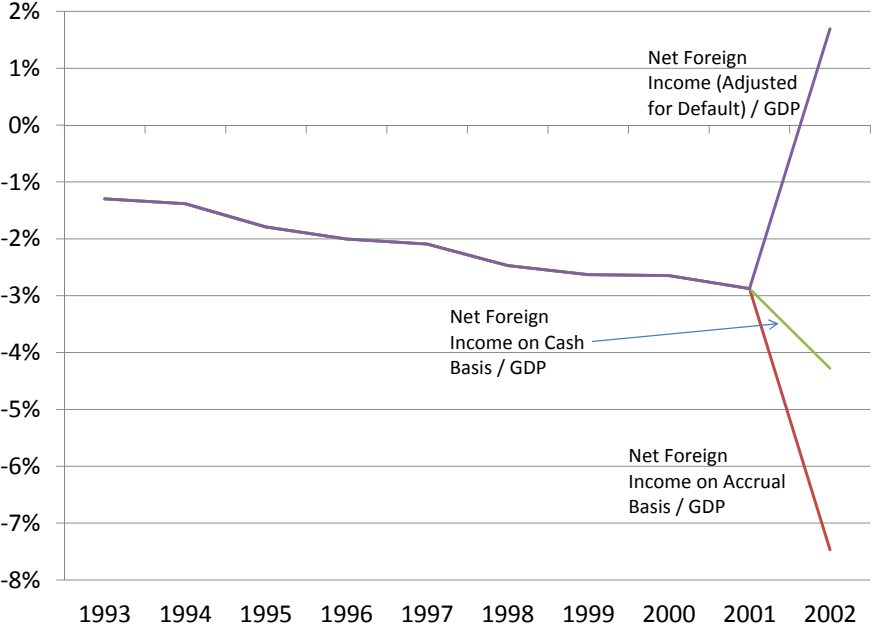

Figure 13: Measures of The Current Account Balance