Producer Prices versus Consumer Prices in the Measurement of Risk Sharing

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Abstract

In empirical research on the measurement of macroeconomic risk sharing there is no agreement on how Gross Domestic Product (GDP), or the corresponding series for regions, should be deflated. We present a stylized theoretical model that illustrates why the appropriate method for deflating nominal GDP (for the purpose of measuring risk sharing) is with a CPI deflator, not with a GDP deflator. We further explain that CPI deflated GDP (the "consumption value" of output) and GDP deflated with a GDP deflator (the volume of output) do represent the same underlying economic series up to measurement error. We illustrate the results estimating the amount of risk shared within subgroups of U.S. states.

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Oved Yosha died from cancer on August 6, 2003. His much too early death is a great loss to all who knew him.

1. Introduction

In the past decade, we have witnessed a wave of empirical research on the measurement of risk sharing among regions and countries.[1] Under standard assumptions, see for instance Sørensen and Yosha (1998), perfect Arrow-Debreu markets imply that all countries (agents, regions,...) have identical growth rates of consumption—we call this situation perfect risk sharing. Following Mace (1991), this has typically been tested by regressing country-specific consumption growth on country-specific output growth, where "country-specific" growth denotes the growth-rate of a variable minus the corresponding aggregate growth-rate. Under perfect risk sharing country-specific consumption growth is zero and examining how closely country-specific consumption growth follows country-specific output growth have become a popular way of quantifying deviations from perfect risk sharing.

The data sets used in these studies typically include time-series of the Gross Domestic Product (GDP) of countries or the corresponding series for regions within countries. Surprisingly, there is no agreement on how these series should be deflated. Some authors use the GDP deflator (or the regional equivalent) to transform the series from nominal to real terms, while others deflate the series with the consumer price index (CPI).[2] The GDP deflator and the CPI deflator are very different, conceptually and empirically, and estimation results are often sensitive to the choice of deflator.[3]

Our goal is to set this debate straight. We present a simple model which illustrates that the appropriate deflator *for the study of risk sharing* is the CPI, and that deflating nominal GDP using the GDP deflator may lead to very different and conceptually flawed results.[4]

Figure 1 about here.

To illustrate our point, we plot in Figure 1 the Gross State Product (GSP) series for several oil-rich U.S. states, deflated with state-specific GDP deflators and with the CPI. During the 1970s and 80s, when oil prices fluctuated considerably, the GSP of these states was subject

[1] There has also been considerable empirical work on risk sharing at the microeconomic level.

[2] In many studies, it is not explicitly mentioned how the series are deflated. In some studies, e.g., Hess and Shin (1998), the GDP deflator is used. In other studies, it is explicitly stated that the CPI is used; see, e.g., Asdrubali, Sørensen, and Yosha (1996), Sørensen, and Yosha (1998), and Kalemli-Ozcan, Sørensen, and Yosha (2003).

[3] Hoffmann (2006) considers explicitly the role of output versus consumer prices in international data.

[4] There are, of course, many settings where it is appropriate to use the GDP deflator, e.g., in the study of capacity utilization, capital accumulation, or economic growth.

to substantial shocks. But when deflated with the GDP deflator, these shocks are not apparent at all. The reason is very simple. For these states, the GDP deflator is basically the price of oil, and using it as a deflator neutralizes the shocks to nominal GSP. However, in the study of interstate risk sharing it is central whether and to what extent oil-price shocks affect the *consumption value* of GSP and the purchasing power of oil-rich versus non-oil states. By contrast, deflating nominal GSP with the CPI preserves shocks to relative prices of goods produced, neutralizing mainly the general rise in the price level of goods consumed.

We, therefore, disagree with Del Negro's (2002) claim that the GSP series for U.S. states, deflated with state-specific GDP deflators and with the CPI, represent two empirical proxies for *the same underlying economic series* with less than perfectly correlated measurement error. Relying on this assumption, Del Negro sets out to correct for measurement error in the panel-data regressions of the form estimated by, *inter alia*, Asdrubali, Sørensen, and Yosha (1996) and Mélitz and Zumer (1999), of the amount of risk sharing achieved among regions within countries. Unfortunately, the central identifying assumption of his empirical model—that GSP deflated with the CPI and with the GSP deflator represent the same underlying economic variable up to measurement error—is incorrect.

In the next section, we present a stylized theoretical model that illustrates why the appropriate manner for deflating nominal GSP (for the purpose of measuring risk sharing) is with a CPI-based deflator.[5] Section 3 illustrates the difference between estimates of risk sharing for U.S. regions calculated using CPI-deflated GSP and the volume of GSP, respectively.

2. Producer Prices versus Consumer Prices: A Stylized Model

For concreteness, we focus on U.S. states. To allow for graphical presentation, we imagine that the U.S. is composed of two regions: one that comprises all the oil-producing states (region X), and another that comprises all the other states (region Y). Region X produces only oil, region Y produces all the other goods, and the regions are engaged in free trade. All the goods are tradable, and there are no trade frictions.[6] Consumers are identical within and across regions, and have homothetic preferences on "oil" (x) and "other goods" (y).

The classification "oil" versus "other goods" is, of course, heuristic. It captures the fact that

[5]Del Negro (2002) provides evidence that using state-specific CPI deflators rather than the U.S. aggregate CPI index has little effect on the empirical results.

[6]Later, we relax the assumption that region X produces *only* oil, and the assumption that all the goods are tradable. Our analysis is robust to these extensions of the model; see the Appendix.

U.S. states, and regions within countries in general, are often highly specialized and subject to region-specific shocks.[7] Oil-price shocks are a typical example. They affect the supply-side in oil-rich states (Alaska, Wyoming), and the demand-side everywhere, but especially in industrialized states, and states with cold winters. An analogous reasoning holds at the country level, with some countries being highly specialized in oil (Norway), telecommunications equipment (Finland), or coffee beans (Columbia).

The period t nominal Gross State Product (GSP) of a region is denoted

$$\text{nominal GSP}_t = \Sigma_j P_t^j Q_t^j ,$$

where Q_t^j is the period t quantity of good j produced in the region, and P_t^j is the period t U.S.-wide price of good j ($j = \text{X}, \text{Y}$).[8] In our stylized model, each region produces only one of these goods; see points Q_t^{X} and Q_t^{Y} in Figure 2, at the respective corners of the transformation schedules of the two regions. The regions trade, and both consume on the U.S.-wide income expansion path corresponding to the price ratio $P_t^{\text{X}} / P_t^{\text{Y}}$; see points $C_t^{(\text{X})}$ and $C_t^{(\text{Y})}$ in Figure 2. There is no saving.

Figure 2 about here

Suppose that in period $t' > t$ prices change (for example, suppose that both prices rise) such that the price ratio increases, $P_{t'}^{\text{X}} / P_{t'}^{\text{Y}} > P_t^{\text{X}} / P_t^{\text{Y}}$, an "oil-price shock." Assume that the *volume* of production in both regions does not change (we relax this later on), namely $Q_t^{\text{X}} = Q_{t'}^{\text{X}} \equiv Q^{\text{X}}$ and $Q_t^{\text{Y}} = Q_{t'}^{\text{Y}} \equiv Q^{\text{Y}}$. Yet, the new price ratio implies that the *consumption value* of production changes in both regions, yielding a new consumption allocation, $C_{t'}^{(\text{X})}$ and $C_{t'}^{(\text{Y})}$ on a less oil-intensive income expansion path; see Figure 2.

How should period t' nominal GSP be deflated? We begin with the GSP deflator (i.e., the region-specific GDP deflator). Until 1995, the BEA estimated GSP using a "fixed-weight"

[7] See Kalemli-Ozcan, Sørensen, and Yosha (2003).

[8] GSP is estimated by the Bureau of Economic Analysis (BEA) as the value of goods and services produced in a state less net purchases of factors of production and intermediate goods and services from other states. In our stylized model, there are no explicit purchases of factors of production and intermediate products across regions. (We can think of Q_t^j as the value of good j produced in the region less net such purchases from the other region.) GSP is the state-level counterpart of U.S. Gross Domestic Product (GDP). It is published by the BEA as part of the U.S. state-level National Accounts; see Beemiller and Downey (2001).

method that we will describe shortly. Since the end of 1995, the BEA switched to a "chain-weight" method which is more precise, but also more complicated (see Landefeld and Parker 1997). To keep the exposition simple, we present our argument using the older "fixed-weight" method. In the Appendix, we show that the argument holds up when the GSP deflator is calculated using the "chain-weight" method.

The period t' (fixed-weight) GSP deflator for base year t is a Paasche price index that weights current and past prices by current quantities:

$$\text{DEF}_t\text{GSP}_{t'} = \frac{\Sigma_j P^j_{t'} Q^j_{t'}}{\Sigma_j P^j_t Q^j_{t'}} .$$

It transforms period t' nominal GSP to period t' real GSP as follows:

$$\begin{aligned} \text{real GSP}_{t'} &= \frac{\text{nominal GSP}_{t'}}{\text{DEF}_t\text{GSP}_{t'}} \\ &= \Sigma_j P^j_{t'} Q^j_{t'} \,/\, \frac{\Sigma_j P^j_{t'} Q^j_{t'}}{\Sigma_j P^j_t Q^j_{t'}} \\ &= \Sigma_j P^j_t Q^j_{t'} . \end{aligned}$$

The resulting real GSP is a weighted average of current quantities by past prices.[9] The GSP deflator thus neutralizes changes in nominal GSP that arise from changes in prices. In this sense, period t' real GSP can be thought of as the period t' *volume* of production, and the resulting time-series of real GSP for periods $t, t', t'', \ldots$ is in fact the time-series of the volume of production in the state under consideration.

We apply these concepts to our stylized model. Nominal GSP in region X, in periods t and t', is $P^{\text{X}}_t Q^{\text{X}}$ and $P^{\text{X}}_{t'} Q^{\text{X}}$, respectively, satisfying

$$P^{\text{X}}_{t'} Q^{\text{X}} > P^{\text{X}}_t Q^{\text{X}} ,$$

and reflecting the rise in the value of region X's (oil) output. Deflating period t' nominal GSP by the region's GSP deflator yields

$$P^{\text{X}}_{t'} Q^{\text{X}} \,/\, \frac{P^{\text{X}}_{t'} Q^{\text{X}}}{P^{\text{X}}_t Q^{\text{X}}} = P^{\text{X}}_t Q^{\text{X}} .$$

[9] Dividing both sides of the above equality by $\Sigma_j P^j_t Q^j_t$, yields the well-known result that deflating (gross) nominal GDP growth by a Paasche price index yields a Laspeyres quantity index. For details, see United Nations, Department of Economic and Social Affairs, Statistics Division, System of National Accounts 1993 (updated version), section XVI: Price and Volume Measures (available at *http://unstats.un.org/unsd/sna1993/toctop.asp*).

In other words, in the case where output is fixed, the GSP deflator simply neutralizes the rise in region X's *consumption value* of production that arose due to the increase in the relative price of oil.

Is this "good" or "bad"? If our goal is to assess the change in physical production in region X, then this is precisely what we want. Our model assumes that, e.g., due to adjustment costs or institutional frictions, the quantity of oil produced in region X does not change when oil's relative price rises. The GSP deflator captures exactly this by reversing the entire increase in the consumption value of region X's output which was caused only by the change in the price of oil, not by any change in the quantity of oil produced.

If, however, we are interested in the change in region X's purchasing power, we do not want to adjust nominal GSP for the change in the value of the region's oil production because the higher value of production allows the residents of region X to purchase more consumption goods on the U.S.-wide market. Shocks—positive or negative—to the prices of oil, hogs, or lumber constitute shocks to the purchasing power of Alaska, Iowa, and Oregon, respectively. Whether, how, and to what extent these shocks are insured are questions that can be answered only if the effect of these shocks on the value of production is not neutralized through the use of state-specific GSP deflators.

Deflating nominal GSP with the (U.S.-wide) CPI achieves precisely that. It corrects for the general U.S.-wide change in prices (we assumed that the price of oil and of all other goods rise), but without neutralizing the rise in the relative value of the oil produced in Region X and the corresponding increase in the region's purchasing power.

The period t' CPI deflator for base year t is a Laspeyres price index that weights current and past prices by past quantities:

$$\text{DEF}_t\text{CPI}_{t'} \;=\; \frac{\Sigma_j P^j_{t'} C^j_t}{\Sigma_j P^j_t C^j_t}\,.$$

In our model, deflating period t' nominal GSP by the CPI deflator, and using $P^{\text{x}}_{t'} Q^{\text{x}} = \Sigma_j P^j_{t'} C^{j(\text{x})}_{t'}$ (i.e., the production and consumption baskets lie on the same budget line), yields

$$P^{\text{x}}_{t'} Q^{\text{x}} \,/\, \frac{\Sigma_j P^j_{t'} C^{j(\text{x})}_t}{\Sigma_j P^j_t C^{j(\text{x})}_t} \;=\; \Sigma_j P^j_t C^{j(\text{x})}_t \, \frac{\Sigma_j P^j_{t'} C^{j(\text{x})}_{t'}}{\Sigma_j P^j_{t'} C^{j(\text{x})}_t} \;=\; P^{\text{x}}_t Q^{\text{x}} \, \frac{\Sigma_j P^j_{t'} C^{j(\text{x})}_{t'}}{\Sigma_j P^j_{t'} C^{j(\text{x})}_t}\,.$$

The graphical and economic interpretation are one and the same. Real-CPI-deflated GSP in period t' is obtained by multiplying the value of period t nominal GSP by a factor that reflects the rise in the purchasing power of region X, which is exactly the ratio of the values of the budget lines denoted "**" and "*" in Figure 2. The difference between the value of these budget lines is nothing but the Slutsky compensation, in "dollars," that would be required to restore region X's purchasing power back to its period t level; i.e., from the budget line through the consumption point $C_{t'}^{(\mathrm{X})}$ to the budget line through the consumption point $C_{t}^{(\mathrm{X})}$, both with slope $P_{t'}^{\mathrm{X}}/P_{t'}^{\mathrm{Y}}$.

The analysis for region Y is symmetric. Nominal GSP in region Y, in periods t and t', is $P_t^{\mathrm{Y}}Q^{\mathrm{Y}}$ and $P_{t'}^{\mathrm{Y}}Q^{\mathrm{Y}}$, respectively, satisfying

$$P_{t'}^{\mathrm{Y}}Q^{\mathrm{Y}} < P_t^{\mathrm{Y}}Q^{\mathrm{Y}} ,$$

reflecting the *fall* in the relative value of the region's output. Deflating period t' nominal GSP by the region's GSP deflator yields

$$P_{t'}^{\mathrm{Y}}Q^{\mathrm{Y}} \,/\, \frac{P_{t'}^{\mathrm{Y}}Q^{\mathrm{Y}}}{P_t^{\mathrm{Y}}Q^{\mathrm{Y}}} = P_t^{\mathrm{Y}}Q^{\mathrm{Y}} .$$

In other words, the GSP deflator neutralizes the fall in region Y's value of production that arose due the fall in the relative price of its output. The real-CPI-deflated GSP for this region can be expressed as, using $P_{t'}^{\mathrm{Y}}Q^{\mathrm{Y}} = \Sigma_j P_{t'}^j C_{t'}^{j(\mathrm{Y})}$,

$$P_{t'}^{\mathrm{Y}}Q^{\mathrm{Y}} \,/\, \frac{\Sigma_j P_{t'}^j C_t^{j(\mathrm{Y})}}{\Sigma_j P_t^j C_t^{j(\mathrm{Y})}} = \Sigma_j P_t^j C_t^{j(\mathrm{Y})} \; \frac{\Sigma_j P_{t'}^j C_{t'}^{j(\mathrm{Y})}}{\Sigma_j P_{t'}^j C_t^{j(\mathrm{Y})}} .$$

In other words, real-CPI-deflated GSP is obtained by multiplying the value of period t nominal GSP by a factor that reflects the fall in the region's purchasing power, which is the ratio of the values of the budget lines denoted "++" and "+" in Figure 2.[10]

In the Appendix. we show that the argument is robust to the use of a chain-weighted GSP deflator and to the presence of non-tradable goods and services.

3. Empirical Illustrations for U.S. States

3.1 Comparison of Growth Rates of CPI-Deflated Output and Quantities

[10]In practice, the calculation of consumption price indices, such as the CPI, are based only on a sample of goods and services consumed. (By contrast, in the calculation of GDP deflators there is an attempt to cover the universe of goods and services produced.) For details, see How the Government Measures the CPI, by Eugene Becker, Bureau of Labor Statistics (available at *http : //economics.about.com/library/chartroom/blcpimeasure.htm*).

Table 1 about here.

Table 1 displays, for each U.S. state, the difference between the growth in the consumption value of production (CPI-deflated GSP) and the growth in the volume of production (GSP deflated with a state-specific GSP deflator). Columns (1)–(4) show average differences in growth-rates for the sub-periods 1977–1982, 1982–1988, 1988–1994, and 1994–2000; while column (5) displays the cumulative difference in the growth rates for 1977–2000. The time frames are chosen to highlight the impact of oil-price shocks (with oil prices rising rapidly in the first sub-period, and reverting in the second). Table 1 further displays, in columns (6)–(8), the average share of GSP over the period 1977–1994 produced in agriculture, mining (including oil), and manufacturing, respectively. The sector-shares are reproduced from Kalemli-Ozcan, Sørensen, and Yosha (2001).

The results in Table 1 exhibit interesting patterns. Most notably, during the earlier time spans, oil-rich states experience large systematic differences in the consumption value versus the volume of GSP. For example, Alaska saw the consumption value of GSP increase 5.8 percent faster *per year* during 1977–1982—a gain that was mostly reversed over the following 5-year period. Wyoming and Louisiana experienced similar patterns. In the longer run, other patterns emerge. For example, one clear finding is that heavily agricultural states, like Iowa, Nebraska, and North Dakota, over the period 1977-2000, experienced about 10 percent slower growth of the consumption value of GSP relative to the volume of GSP, presumably due to a decline in the relative price of agricultural goods.

Much more could be said about these patterns, but for the purpose of the present article we simply stress that the differences in the growth rates of the consumption value and the volume of output, for many states at least, do not have the appearance of independent (across states and time) measurement errors as assumed in Del Negro's (2002) empirical model.

3.2 Estimating Regional Risk Sharing using CPI-Deflated Output versus Quantity Index

To measure the degree of deviation from full risk sharing, we estimate the panel-data regression

$$c_{it} - c_t = \alpha + \beta \left(gsp_{it} - gsp_t \right) + u_{it},$$

where c_{it} is the growth rate of state-level consumption in CPI-deflated per capita terms and c_t

is "aggregate" consumption.[11] "Aggregate" is the aggregate per capita consumption growth of the group of states for which we decide to examine risk sharing—we examine several aggregates below of which the aggregate United States is one. gsp_{it} and gsp_t is the growth rate of state-level per capita GSP and aggregate GSP, respectively. GSP is deflated with *either* CPI *or* the implicit GDP-delator that converts GSP into a quantity index. β measures the degree of deviation from perfect risk sharing and we present $100 \times \beta$ which we refer to as the percent of risk not shared. This number will be 100 if consumption follows output one-to-one and 0 if there is perfect risk sharing because the left-hand side of the regression then is zero.

We show results for risk sharing between all 50 U.S. states and results for risk sharing within the four regions "East," "Central," "South," and "West."[12] These results (for CPI-deflated output) update results presented in Sørensen and Yosha (2000) to more recent data.

Table 2 about here.

The results are presented in Table 2. For risk sharing between all 50 states, we find a six percentage points higher number for risk not shared using the quantity index. For the four regions we find that the risk sharing estimates are quite similar except for West. Because oil-prices fluctuated substantially during our sample period we expect West, where most oil-states are located, to have a higher amount of risk sharing when we measure risk sharing using CPI-deflated GSP. This is because the quantity index misses a lot of the fluctuations in the consumption value of output and there, therefore, is less risk to share. This is what we observe: the percentage risk not shared is higher, at 35 percent, for the quantity index than for CPI-deflated output (27 percent).

We expect that the distortions from using a quantity index may be more easily seen in smaller groups of states and we, therefore also show results for 8 smaller groups of states; namely, the eight regions defined by the BEA (except that we leave out the District of Columbia): New England (CT, MA, ME, NH, RI, VT); Mideast (DE, MD, NJ, NY, PA); Great Lakes (IL, IN, MI, OH, WI); Plains (IA, KS, MN, MO, ND, NE, SD); Southeast (AL, AR, FL, GA, KY, LA,

[11]The consumption data are calculated from retail-sales by state and state government consumption. See Asdrubali, Sørnsen, and Yosha (1996) for details—the present data are updated to 1998 following the procedures of that paper.

[12]In terms of the U.S. postal codes (easily available on the internet) the state groupings are: East: CT, MA, ME, NH, RI, VT, DE, MD, NJ, NY, and PA; Central: IL, IN, MI, OH, WI, IA, KS, MN, MO, NB, ND, and SD; South: AL, AR, FL, GA, KY, LA, MS, NC, SC, TN, VA, and WV; West: AZ, NM, OK, TX, CO, ID, MT, UT, WY, AK, CA, HI.

MS, NC, TN, VA, WV); Southwest (AZ, NM, OK, TX); Rocky Mountain (CO, ID, MT, UT, WY); and Far West: (AK, CA, HI, NV, OR, WA). We will label these regions by the numbers 1–8. The results are presented in Table 3.

Table 3 about here.

In this table, the oil-states are in regions 7 and 8 and we see again that for these regions the estimates are highly dependent on what deflator is used. Overall, it is clear that the choice of deflator matters for states where the structure of output is dominated by raw materials with variable prices.

4. Concluding Remarks

Our main goal has been to illustrate that the appropriate manner to deflate nominal GDP *for the study of risk sharing* is with the CPI, and that deflating nominal GDP using the GDP deflator is conceptually flawed and may yield biased results. We stress that there are many settings where using the GDP deflator is highly appropriate, for instance in the study of economic growth where the physical volume of output may be of greater interest than (potentially temporary) fluctuations in its value. But when estimating risk sharing, it is of great interest to study how the risk from relative price shocks, that benefit some regions or countries and not others, are insured. Deflating GDP with the GDP deflator "spills the baby with the bath water" by adjusting for these shocks, while deflating with the CPI preserves them.

A. Appendix: Extensions of the Stylized Model in Section 2

Allowing for changes in the volume of production. Figure 3 displays an analogous model where Region X produces oil and other goods, and its production mix becomes more oil-intensive in response to the rise in oil's relative price.

Figure 3 about here.

Deflating period t' nominal GSP by the GSP deflator yields

$$\Sigma_j P^j_{t'} Q^j_{t'} \,/\, \frac{\Sigma_j P^j_{t'} Q^j_{t'}}{\Sigma_j P^j_t Q^j_{t'}} \;=\; \Sigma_j P^j_t Q^j_{t'}\,,$$

which is the line denoted by "*" in Figure 3. In other words, the GSP deflator *lowers* region X's value of production relative to its value before the price change, which is absolutely senseless. A rise in the price of oil should under no circumstances be measured as a negative shock to the GSP of an oil-rich state!

Chain-weighted GSP deflator. Consider the following period t' GSP deflator for base year t:

$$\text{chain-weighted } \mathrm{DEF}_t\mathrm{GSP}_{t'} \;=\; \sqrt{\frac{\Sigma_j P^j_{t'} Q^j_{t'}}{\Sigma_j P^j_t Q^j_{t'}} \; \frac{\Sigma_j P^j_{t'} Q^j_t}{\Sigma_j P^j_t Q^j_t}}\,.$$

This deflator is a geometric average of $\mathrm{DEF}_t\mathrm{GSP}_{t'}$ displayed earlier, a Paasche price index that weights current and past prices by current quantities, and a Laspeyres price index that weights current and past prices by past quantities. It is called "chain-weighted" because the base year changes from year to year, thus avoiding that the base year quantities or prices are far back in the past. The BEA has been using this index since 1995. (The official state-level real GSP time-series, available for 1977 and onwards, are constructed in this manner.)

In our stylized model, deflating period t' nominal GSP of region X with the chain-weighted index yields

$$P^{\mathrm{X}}_{t'} Q^{\mathrm{X}} \,/\, \sqrt{\frac{P^{\mathrm{X}}_{t'} Q^{\mathrm{X}}}{P^{\mathrm{X}}_t Q^{\mathrm{X}}} \; \frac{P^{\mathrm{X}}_{t'} Q^{\mathrm{X}}}{P^{\mathrm{X}}_t Q^{\mathrm{X}}}} \;=\; P^{\mathrm{X}}_t Q^{\mathrm{X}}\,,$$

which also neutralizes the rise in region X's value of production that arose due to the increase in the price of oil, an undesirable feature in the empirical study of risk sharing.

Non-tradable goods and services. Suppose that regions X and Y produce a non-tradable commodity ("services") and a tradable good, "oil" and "other goods," respectively. In each region, the consumption basket comprises of locally produced services, and internationally traded oil and other goods. To focus on a well-defined model, we adopt the central feature of the classic Balassa-Samuelson framework: there is one factor of production—labor—which is fully mobile across sectors within each region but immobile across regions. An "oil-price shock" raises wages in the tradable sector (oil) in region X, and hence also in the non-tradable sector in the region, entailing a rise in the local price of services. This rise in prices partially offsets the increase in the purchasing power of the region. Deflating the region's nominal GSP with the CPI deflator captures both changes in the price of consumption—due to the oil-price increase and the ensuing rise in the price of services, appropriately weighted to reflect their respective shares in consumption. This yields a correct estimate of the net positive shock to the value (purchasing power) of region X's GSP. By contrast, deflating the region's nominal GSP with the GSP deflator would neutralize the impact of the oil-price shock because the GSP deflator ignores the fact that region X exports oil and purchases "other goods" from region Y with the proceeds. '

References

Asdrubali, P./*Sørensen*, B.E./*Yosha*, O. (1996): "Channels of interstate risk sharing: United States 1963–90," Quarterly Journal of Economics 111, 1081–1110.

Beemiller, R.M./*Downey*, G.K. (2001): "Gross state product by industry, 1992–99," Survey of Current Business 81, 159–172.

Del Negro, M. (2002): "Asymmetric shocks among U.S. states," Journal of International Economics 56, 273–297.

Hess, G./*Shin*, K. (1998): "Intranational business cycles in the United States," Journal of International Economics 44, 289–313.

Hoffmann, M. (2007): "The lack of international consumption risk sharing: can inflation differentials and trading costs help explain the puzzle?" Forthcoming: Open Economics Review.

Kalemli-Ozcan, S./*Sørensen*, B.E./*Yosha*, O. (2001): "Economic integration, industrial specialization, and the asymmetry of macroeconomic fluctuations," Journal of International Economics 55, 107–137.

Kalemli-Ozcan, S./*Sørensen*, B.E./*Yosha*, O. (2003): "Risk sharing and industrial specialization: regional and international evidence," American Economic Review 93, 903–918.

Landefeld, S./*Parker*, R. (1997): "BEA's term indexes, time-series, and measures of long-term economic growth," Survey of Current Business, May,
(available at http://www.bea.doc.gov/bea/an/0597od/maintext.htm).

Mace, B.J. (1991): "Full insurance in the presence of aggregate uncertainty," Journal of Political Economy 99, 928–956.

Mélitz, J./*Zumer*, F. (1999): "Interregional and international risk sharing and lessons for EMU," Carnegie-Rochester Conference Series on Public Policy 51, 149–188.

Sørensen, B.E./*Yosha*, O. (1998): "International risk sharing and European monetary unification," Journal of International Economics 45, 211–238.

Sørensen, B.E./*Yosha*, O. (2000): "Is risk sharing in the United States a regional phenomenon?" Federal Reserve Bank of Kansas City Economic Review, Second Quarter, 33–47.

Table 1: Difference in Growth of the Consumption Value of GSP and the Volume of GSP.

States	(1) average difference 77–82	(2) average difference 82–88	(3) average difference 88–94	(4) average difference 94–00	(5) cumulative difference 77–00	(6) Agriculture GSP Share	(7) Mining GSP Share	(8) Manufacturing GSP Share
Alabama	-0.5	0.3	-0.1	0.0	-1.1	2.37	2.40	24.03
Alaska	5.8	-5.5	-0.3	2.0	6.1	1.55	30.98	3.98
Arizona	-0.3	0.7	-0.1	-0.7	-2.0	2.40	1.93	13.60
Arkansas	-0.6	-0.1	-0.2	-0.3	-6.1	5.67	1.88	24.71
California	-0.4	0.5	0.1	-0.2	0.4	2.33	1.26	16.29
Colorado	-0.0	0.4	0.0	0.1	3.3	2.31	3.25	13.01
Connecticut	-0.5	0.7	0.4	-0.0	3.9	0.66	0.13	23.82
Delaware	-0.1	0.8	0.6	1.1	14.9	1.49	0.05	28.05
Florida	-0.5	1.0	0.2	0.1	5.7	2.61	0.67	10.13
Georgia	-1.0	0.8	-0.0	0.2	0.7	1.96	0.52	20.31
Hawaii	-0.1	1.5	0.2	0.4	12.9	1.95	0.05	4.38
Idaho	-1.3	0.3	-0.2	-1.5	-15.3	8.93	1.52	17.20
Illinois	-0.7	0.3	-0.0	-0.3	-3.7	1.88	0.82	21.51
Indiana	-0.9	0.1	-0.1	-0.4	-7.2	2.52	0.73	32.18
Iowa	-1.7	-0.1	-0.3	-0.7	-14.9	9.27	0.21	24.51
Kansas	0.0	-0.1	0.0	0.0	-0.4	5.24	3.23	18.66
Kentucky	-1.0	-0.0	-0.2	-0.0	-6.8	3.60	5.86	27.18
Louisiana	4.1	-3.1	0.0	1.5	10.5	1.37	19.30	15.38
Maine	-0.5	0.8	0.2	0.3	5.1	2.54	0.04	21.44
Maryland	-0.4	1.0	0.4	0.3	8.2	1.05	0.13	11.84
Massachusetts	-0.6	0.6	0.2	-0.2	0.2	0.67	0.05	21.81
Michigan	-0.3	0.1	0.3	-0.2	-0.3	1.30	0.78	31.77
Minnesota	-1.1	0.2	-0.0	-0.2	-5.6	4.52	0.98	21.86
Mississippi	-0.2	-0.4	-0.0	-0.1	-4.4	3.93	3.13	22.99
Missouri	-0.7	0.5	0.1	-0.1	-0.4	2.70	0.46	22.43
Montana	0.3	-0.4	-0.3	-0.0	-2.7	6.68	8.73	8.21
Nebraska	-1.4	0.2	-0.3	-0.3	-9.5	10.31	0.36	14.29
Nevada	0.1	1.3	-0.0	0.7	12.1	0.93	3.28	4.62
New Hampshire	-0.8	0.2	0.0	-0.9	-7.7	0.83	0.12	25.17
New Jersey	-0.5	0.7	0.2	0.0	2.6	0.55	0.07	20.41
New Mexico	3.0	-1.5	-0.5	-1.4	-5.5	2.36	15.31	7.15
New York	-0.5	1.1	0.3	-0.6	2.4	0.58	0.13	16.05
North Carolina	-0.9	1.0	0.1	0.4	4.4	2.57	0.28	32.09
North Dakota	0.9	-1.5	-0.3	-0.1	-7.0	11.51	9.00	5.90
Ohio	-0.6	0.0	0.0	-0.3	-4.8	1.36	0.94	30.70
Oklahoma	2.1	-1.8	-0.1	0.2	0.8	3.04	11.95	15.62
Oregon	-0.8	0.7	0.2	-1.6	-8.5	3.47	0.19	21.39
Pennsylvania	-0.6	0.5	0.2	0.0	1.0	1.17	1.14	23.51
Rhode Island	-0.3	0.7	0.3	0.3	6.2	0.94	0.06	23.87
South Carolina	-1.0	0.4	-0.2	-0.1	-4.6	1.64	0.23	27.97
South Dakota	-1.5	0.7	-0.3	-0.5	-7.7	13.65	1.52	10.02
Tennessee	-0.9	0.4	0.1	-0.1	-2.1	1.88	0.60	25.78
Texas	2.4	-1.5	-0.2	0.3	3.7	1.78	11.80	15.99
Utah	0.1	-0.0	-0.1	0.2	1.0	1.57	5.21	14.71
Vermont	-0.9	0.6	-0.2	-0.5	-5.6	3.29	0.36	22.17
Virginia	-0.4	1.2	0.2	0.6	10.5	1.22	1.17	17.55
Washington	-0.6	0.9	0.3	0.2	5.6	3.23	0.23	17.11
West Virginia	-0.3	-0.9	-0.7	-0.3	-12.8	0.84	14.14	18.05
Wisconsin	-1.2	0.1	-0.1	-0.4	-8.5	3.94	0.16	29.96
Wyoming	4.6	-4.7	-1.3	0.9	-8.2	2.57	35.56	3.97

Notes: Columns (1)-(4) display the average annual rate of growth of GSP per capita deflated by the CPI minus the average annual rate of growth of GSP deflated by the GSP deflator. Column (5) displays the corresponding cumulative difference for 1977–2000. The series GSP deflated by the GSP deflator have been adjusted (downwards) each year by the ratio of the average (across states) GSP deflator to the CPI in order to focus on the relative patterns across states.
The shares of agriculture, mining (including oil), and manufacturing are shares of the corresponding sector in nominal GDP, averaged over the period 1977–1994.

Table 2: Consumption Risk Sharing Within U.S. Regions.

Percent Risk Not Shared.

	Within US	Within Regions			
Region:		East	Central	South	West
GSP measure:					
GSP/CPI	29	7	4	15	27
	(4)	(15)	(8)	(8)	(5)
Quantity Index	35	10	6	16	35
	(5)	(15)	(8)	(11)	(8)

Notes. Regions: East, Central, South, and West are aggregates of the regions used by the BEA. In terms of the U.S. postal codes the state groupings are: East: CT, MA, ME, NH, RI, VT, DE, MD, NJ, NY, and PA; Central: IL, IN, MI, OH, WI, IA, KS, MN, MO, NB, ND, and SD; South: AL, AR, FL, GA, KY, LA, MS, NC, SC, TN, VA, and WV; West: AZ, NM, OK, TX, CO, ID, MT, UT, WY, AK, CA, HI. Sample: 1977–99. The table displays the coefficient β in the regression $c_{it} - c_t = \alpha + \beta(gsp_{it} - gsp_t) + u_{it}$, where c_{it} is the growth rate of state-level consumption in CPI-deflated per capita terms and c_t is "aggregate" consumption. "Aggregate" is the aggregate per capita consumption growth of the relevant group of states. $(gsp_{it}$ and $(gsp_t$ is the growth rate of state-level per capita GSP and aggregate GSP, respectively. GSP is deflated with *either* CPI (top of table) *or* the implicit GDP-delator that converts GSP into a quantity index (bottom of table). β measures the degree of deviation from perfect risk sharing and we present $100 \times \beta$ which we refer to as the percent of risk not shared. This number will be 100 if consumption follows output one-to-one and 0 if there is perfect risk sharing. Standard errors in parenthesis.

Table 3: Consumption Risk Sharing Within U.S. Regions.

Percent Risk Not Shared.

	Within Regions							
Region:	1	2	3	4	5	6	7	8
GSP measure:								
GSP/CPI	5	4	4	1	15	24	23	26
	(20)	(19)	(18)	(8)	(8)	(13)	(17)	(9)
Quantity	7	9	1	0	16	24	7	40
Index	(20)	(18)	(19)	(8)	(11)	(16)	(22)	(13)

Notes. Regions: Eight BEA regions: New England (CT, MA, ME, NH, RI, VT); Mideast (DE, MD, NJ, NY, PA); Great Lakes (IL, IN, MI, OH, WI); Plains (IA, KS, MN, MO, ND, NE, SD); Southeast (AL, AR, FL, GA, KY, LA, MS, NC, TN, VA, WV); Southwest (AZ, NM, OK, TX); Rocky Mountain (CO, ID, MT, UT, WY); and Far West: (AK, CA, HI, NV, OR, WA). We label these regions 1–8 in this order. Sample: 1977–98. The table displays the coefficient β in the regression $c_{it} - c_t = \alpha + \beta(gsp_{it} - gsp_t) + u_{it}$, where c_{it} is the growth rate of state-level consumption in CPI-deflated per capita terms and c_t is "aggregate" consumption. "Aggregate" is the aggregate per capita consumption growth of the group of states used in the relevant region. gsp_{it} and gsp_t is the growth rate of state-level per capita GSP and aggregate GSP, respectively. GSP is deflated with *either* CPI (top of table) *or* the implicit GDP-delator that converts GSP into a quantity index (bottom of table). β measures the degree of deviation from perfect risk sharing and we present $100 \times \beta$ which we refer to as the percent of risk not shared. This number will be 100 if consumption follows output one-to-one and 0 if there is perfect risk sharing. Standard errors in parenthesis.