# Can Trade Costs Explain Why Exchange Rate Volatility Doesn't Feed Into Consumer Prices?

Doireann Fitzgerald[*][†]

Department of Economics, Stanford University

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**Abstract**

If countries specialize in imperfectly substitutable goods, trade costs increase the share of expenditure devoted to domestic output, reducing the exposure of consumer price inflation to exchange rate changes. I present a multi-country flexible-price model where expenditure shares are inversely related to trade costs through a gravity equation. In this setting, consumer price inflation can be approximated as an expenditure share weighted average of the contributions to inflation from all countries. I use data from 24 OECD countries, 1970-2003, to estimate a structural gravity model. I combine the fitted expenditure shares from the estimation with actual data on exchange rates to construct predictions of inflation. The behavior of these predictions indicates that trade costs can explain both qualitatively and quantitatively the failure of exchange rate volatility to feed into inflation.

*Keywords:* Exchange rate disconnect, Trade costs, Gravity

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[*]Department of Economics, Stanford University, Stanford, CA 94305, dfitzger at stanford dot edu

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## 1. Introduction

Since Mussa (1986) pointed out that the behavior of real exchange rates differs sharply across exchange rate regimes, many papers have documented that the volatility of floating nominal exchange rates neither reflects nor feeds back into the volatility of other macroeconomic variables. Baxter and Stockman (1989) "find little evidence of systematic differences in the behavior of macroeconomic aggregates" such as output, consumption, trade flows and government consumption across exchange rate regimes, despite the big differences in real exchange rate behavior. Flood and Rose (1995) update the evidence and come to the same conclusion. The extent to which nominal exchange rate changes feed into inflation in particular has been examined in detail by the literature on testing for purchasing power parity. The conclusion of this literature, as summarized by Froot and Rogoff (1995), and more recently by Taylor and Taylor (2004), is that exchange rate changes feed into inflation slowly at best.

Explanations for the failure of exchange rate volatility to feed back into inflation and other macro variables can be divided into two categories. The first are based on failures of the law of one price at the level of individual goods, due to sticky prices or pricing to market. The second category consists of those that rely on composition effects when individual goods are imperfectly substitutable. This category includes home bias in preferences, non-traded goods, distribution costs, and trade costs. The first set of explanations face the problem that the order of magnitude of exchange rate variation requires firms to support large and persistent deviations of prices from marginal cost. They are also somewhat at odds with evidence that suggests that pass-through of exchange rate changes into import prices at the border is relatively swift (e.g., Campa and Goldberg, 2005). Moreover, Atkeson and Burstein (2007) demonstrate that, for shocks of small magnitude, the net effect of pricing to market on real exchange rate volatility may be small.

The second category of explanations does not suffer from these problems, and has had some empirical success. Hau (2002) presents a model in which openness to trade depends on preferences, and feedback from exchange rate volatility to inflation is increasing in openness. The prediction that real exchange rate volatility is decreasing in openness is confirmed in the data. The distribution cost literature (e.g., Burstein, Neves and Rebelo, 2003, Campa and Goldberg, 2006, and Corsetti and Dedola, 2005) provides evidence that measured costs of distribution can go a substantial way towards explaining the sluggish response of consumer prices to exchange rate changes. The drawback to both of these explanations is that a country's degree of openness is treated as exogenous. In contrast, the advantage of an explanation based on trade costs is that openness is modeled as endogenous, depending on both size and distance from other countries.

The trade cost hypothesis has been previously highlighted by Obstfeld and Rogoff (2000), who discuss the possible role of trade frictions in explaining several puzzles in international finance, including the exchange rate disconnect puzzle. Several authors have investigated the quantitative importance of trade costs in two-country calibration exercises (Betts and Kehoe, 2001, and Atkeson and Burstein, 2007). These authors find that trade costs are important in explaining real exchange rate behavior. However, to date, no-one has undertaken a cross-country exploration of the ability of trade costs to explain quantitatively the failure of exchange rate volatility to feed back into inflation. The contribution of this paper is to do just this.

I quantify the effect of trade costs on the feedback from exchange rates to inflation using a partial equilibrium calibration exercise. To motivate this exercise, I present a multi-country model with specialization in imperfectly substitutable goods, and costly trade (a structural "gravity" model). Pass-through of exchange rate changes at the border is assumed to be instantaneous. In this framework, consumer price inflation can be approximated as an expenditure-share-weighted average of the contributions to inflation from all the countries from which goods are imported, including the home country. The expenditure shares are a function of the output of the exporting country, the bilateral trade cost between importer and exporter, and in the case of preference heterogeneity, of preference parameters.

Based on this approximation of inflation, I construct "predictions" of CPI inflation using weighted averages of actual data on exchange rate changes and GDP deflator inflation. By using three different sets of weights, I can impose three different sets of assumptions about preference heterogeneity and trade costs. Measured expenditure shares ("actual shares") capture all possible determinants of differences in expenditure patterns, including different preferences, non-traded goods and distribution costs. Shares constructed from the fitted values from a gravity model of trade ("gravity shares") impose the assumption that expenditure patterns differ because of trade costs alone. The case of zero trade costs (and no other sources of cross-country expenditure differences) is captured by using shares of world GDP as weights ("GDP shares").

The first and second moments of these three sets of predictions are compared with the moments of actual CPI inflation. The volatility of the actual shares and gravity shares predictions closely match the volatility of CPI inflation - the actual shares prediction is on average only 6% more volatile than actual inflation, while the gravity shares prediction is 8% more volatile. Meanwhile, the GDP shares prediction is considerably more volatile than CPI inflation - on average 125% more volatile. I conclude that trade costs can go a long way towards explaining the low feedback from exchange rate volatility to CPI inflation. Moreover, I demonstrate that the role of trade costs in shifting expenditure away from imports towards domestic output is key. In this sense, the trade cost explanation works in exactly the same way as home bias in preferences, non-traded goods or distribution costs.

The paper is organized as follows. The second section describes the gravity model, and shows how it can be used to analyze the relationship between inflation and exchange rates. The third section describes in detail the methodology and data used in the calibration exercise. The fourth section presents the results. The fifth section briefly describes a number of robustness checks. The final section concludes.

## 2. Trade costs and expenditure patterns

The structural gravity model described here closely follows Anderson and van Wincoop (2003). There are $N$ countries in the world, indexed $i = 1, \ldots, N$. Each country is endowed with a distinct tradeable intermediate good, also indexed $i$. A non-traded aggregate good is produced by combining these intermediates using a Dixit-Stiglitz production function. The weights on different inputs in this production function may differ across countries. This setup is isomorphic to one where countries are endowed with different final goods, and preferences are Dixit-Stiglitz over these goods. Differences in input weights are analogous to allowing for heterogeneous preferences across countries. The presentation in terms of intermediates reflects the fact that most final goods embody both home and foreign value added.

There is an iceberg cost of trade, so relative prices of the intermediates differ across countries. However all prices are perfectly flexible, and the law of one price holds for intermediates up to the order of the trade cost. For simplicity, the exposition assumes a single world currency. The model is partial equilibrium, in the sense that the relationship between current GDP and current expenditure is taken as given, rather than being derived from intertemporal optimization.

### *2.1. Production*

Country $i$ is endowed with $Y_i$ units of intermediate good $i$. The production function for the aggregate good is given by:

$$X_i = \left[\sum_{k=1}^{N} \left(\lambda(k)_i Z(k)_i\right)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}} \tag{1}$$

where $X_i$ is output of the aggregate good in country $i$, $Z(k)_i$ is the quantity of good $k$ used in production and $\lambda(k)_i$ are parameters that may differ across countries. If $\lambda(k)_i = 1\ \forall i, k$, the production function is the same in all countries. For simplicity, the case of different $\lambda$'s will be referred to as "preference heterogeneity." The elasticity of substitution $\eta$ is assumed greater than 1.[1] The market for the aggregate good is perfectly competitive, so its price $P_i$ (the aggregate price level) is equal to marginal cost:

$$P_i = \left[\sum_{k=1}^{N} \left(P(k)_i / \lambda(k)_i\right)^{1-\eta}\right]^{\frac{1}{1-\eta}} \tag{2}$$

where $P(k)_i$ is the price of intermediate good $k$ in country $i$. Demands for individual intermediate goods take the constant price elasticity form

$$Z(k)_i = \left(\frac{P(k)_i / \lambda(k)_i}{P_i}\right)^{-\eta} X_i \tag{3}$$

[1] The reduced form of this Armington set-up is identical to that of a model with production and increasing returns-driven specialization where the $\eta > 1$ assumption is natural.

### 2.2. *Trade costs*

There is an iceberg cost of trade, assumed to be increasing in the economic distance between countries. When this cost is non-zero, relative prices differ across countries. The relationship between the price of good $k$ in country $i$ and its price in country $k$ is given by:

$$\tau_{ik} P(k)_i = P(k)_k \tag{4}$$

where $\tau_{ik}$ is one plus the fraction that "melts" en route, $\tau_{ik} \geq 1$, $\tau_{ii} = 1$. Because of trade costs, the resource constraint for good $i$ is given by:

$$Y_i = \sum_{k=1}^{N} \tau_{ki} Z(i)_k \tag{5}$$

The resource constraints for all other goods are analogous.

In this world, the law of one price fails in levels, though it holds in differences if trade costs are constant. The aggregate price level is given by:

$$P_i = \left[ \sum_{k=1}^{N} \left( \left( \tau_{ik} / \lambda(k)_i \right) P(k)_k \right)^{1-\eta} \right]^{\frac{1}{1-\eta}} \tag{6}$$

Purchasing power parity fails (both in levels and differences) in the presence of preference heterogeneity, trade costs, or both. The effect of trade costs on price differences is similar to the effect of differences in the $\lambda$'s.

The assumption that there is a single uniform per unit trade cost for each bilateral pair is a simplification. In reality, trade costs vary by sector as well as by bilateral pair. But $\tau_{ik}$ can be thought of as the import-volume-equivalent uniform bilateral trade cost, as in the literature on measuring the restrictiveness of trade policy (Anderson and Neary, 2005, Chapter 10).

### 2.3. *Expenditure shares*

The value share of the $k$th intermediate in $i$'s expenditure is given by a gravity relationship:

$$\frac{IM_{ik}}{EXP_i} = \frac{\tau_{ik} P(k)_k Z(k)_i}{P_i X_i} = \frac{GDP_k}{GDP_W} \left( \frac{P_i \Pi_k}{\tau_{ik} / \lambda(k)_i} \right)^{\eta-1} \tag{7}$$

with

$$\Pi_k^{1-\eta} = \sum_{j=1}^{N} \left( \frac{\tau_{jk} / \lambda(k)_j}{P_j} \right)^{1-\eta} \frac{EXP_j}{GDP_W} \tag{8}$$

where $IM_{ik}$ denotes the value of $i$'s imports from $k$ if $i \neq k$, and $i$'s expenditure on the domestic produced intermediate if $i = k$. $EXP_i = P_i X_i$ denotes country $i$'s total expenditure on all goods. $GDP_k = P(k)_k Y_k$ denotes the GDP of country $k$, while $GDP_W$ denotes the value of world GDP.

With the exception of the $\lambda(k)_i$ term, this is a standard gravity equation. Bilateral imports as a share of importing-country expenditure are increasing in the exporting country's share of world GDP. They are decreasing in bilateral trade costs. Conditioning on these variables (and on the $\lambda$'s), bilateral imports are positively related to the resistance of both importing and exporting countries to trade, as measured by $P_i$ and $\Pi_k$. This is the phenomenon called *multilateral resistance* by Anderson and van Wincoop (2003).

It follows directly from (7) that expenditure patterns differ across countries. The larger is $\lambda(k)_i$, the greater the fraction of $i$'s expenditure devoted to imports from $k$. As regards trade costs, all else equal, a higher fraction of expenditure is devoted to intermediates from countries that are "close" than from countries that are "far." In particular, a disproportionate fraction of expenditure is devoted to the domestic intermediate, given the assumption that $\tau_{ii} = 1$. Expenditure patterns also differ because of the multilateral resistance terms.

In the zero trade cost, no preference heterogeneity case, ($\tau_{ik} = 1$ and $\lambda(k)_i = 1\ \forall i, k$), expenditure shares reduce to

$$\frac{IM_{ik}}{EXP_i} = \frac{P(k)_k Z(k)_i}{P_i X_i} = \frac{P(k)_k Y_k}{\sum_{j=1}^{N} P(j)_j Y_j} = \frac{GDP_k}{GDP^W} \tag{9}$$

In this case, expenditure shares are the same everywhere.[2]

### *2.4. Generalized PPP*

Although standard PPP fails, there is a systematic relationship between domestic consumer price inflation and output price inflation in all countries. Taking the log derivative of the price index, holding the $\lambda$'s and trade costs constant, consumer price inflation can be written:

$$d\ln P_i = \sum_{k=1}^{N} \frac{IM_{ik}}{EXP_i} d\ln P(k)_k = \sum_{k=1}^{N} \frac{GDP_k}{GDP^W} \left( \frac{P_i \Pi_k}{\tau_{ik}/\lambda(k)_i} \right)^{\eta-1} d\ln P(k)_k \tag{10}$$

where $d\ln P(k)_k$ is inflation in country $k$'s GDP deflator.[3]

### *2.5. Money and nominal exchange rates*

When different countries use different currencies, nominal exchange rates must be used to convert GDP and prices to a common currency. In this partial equilibrium setting, the determination of nominal exchange rates is not modeled. The generalized PPP relationship becomes:

$$d\ln P_i = \sum_{k=1}^{N} \frac{E_{ik} GDP_k}{GDP^W} \left( \frac{P_i E_{ik} P_k}{\tau_{ik}/\lambda(k)_i} \right)^{\eta-1} \left[ d\ln E_{ik} + d\ln P(k)_k \right] \tag{11}$$

Even if bilateral nominal exchange rates are highly volatile, at least one term in the sum on the left hand side of (11) - the term where $i = k$ - has a volatility of the same order of magnitude of that of consumer price inflation. So as long as some portion of expenditure is devoted to domestic output, consumer price inflation will be tend to be less volatile than bilateral nominal exchange rates. Trade costs or home bias (high $\lambda(i)_i$) both imply that the fraction of expenditure devoted to domestic output is large, and hence imply a low pass-through of exchange rate volatility into inflation. Note that the assumption of imperfect substitutability between home and foreign output is key. With infinite substitutability, there is one-for-one pass through of exchange rate volatility.

## 3. Empirical strategy

This section describes a calibration exercise designed to examine whether trade costs can explain quantitatively the failure of exchange rate volatility to feed into inflation. I take an explicitly partial equilibrium approach. Following a Tornqvist discrete time approximation of (11), weighted averages of historical data on exchange rate changes and GDP deflator inflation are used to "predict" inflation. Different assumptions about the role of trade costs and cross-country variation in production functions are captured by using different sets of weights. Throughout, the assumption of instantaneous pass-through of exchange rates into import prices at the dock is maintained.

Three different sets of weights are used. The first set of weights are measured expenditure shares. As a matter of accounting, these shares capture the effect of *all* determinants of differences in expenditure

[2] To see this, normalize the aggregate price level $P_i$ (which is now equal to $P_k$) to 1.

[3] A corollary of (10) is that bilateral exchange rates are cross-sectionally dependent, and need not be mean-reverting. First-generation panel unit root tests of the type frequently used in the empirical exchange rate literature may not be robust to this (O'Connell, 1998). (10) can also explain the sensitivity of tests for purchasing power parity based on bilateral exchange rates to the choice of numeraire currency, and why purchasing power parity is less likely to be rejected for country-pairs that are close together than for country-pairs that are distant (Engel and Rogers, 1995).

patterns across countries. This includes (but is not limited to) preference heterogeneity and trade costs. Using these shares as weights yields the "actual shares" CPI inflation prediction:

$$\hat{\pi}_{it}^{ACT} = \sum_{k=1}^{N} \frac{1}{2} \left[ \frac{IM_{ikt}}{EXP_{it}} + \frac{IM_{ikt-1}}{EXP_{it-1}} \right] \left[ \Delta \ln E_{ikt} + \Delta \ln P(k)_{kt} \right] \tag{12}$$

In what follows, $\Delta \ln E_{ikt} + \Delta \ln P(k)_{kt}$ is referred to as $k$'s *contribution* to $i$'s inflation.

The second set of weights captures only that part of expenditure patterns that can be explained by variables that are correlated with trade costs. These weights are obtained by estimating equation (7) imposing the restriction that $\lambda(k)_i = 1 \; \forall i, k$. The fitted values of this gravity equation are then used to construct the "gravity shares" inflation prediction:

$$\hat{\pi}_{it}^{GRAV} = \sum_{k=1}^{N} \frac{1}{2} \left[ \frac{\widehat{IM_{ikt}}}{EXP_{it}} + \frac{\widehat{IM_{ikt-1}}}{EXP_{it-1}} \right] \left[ \Delta \ln E_{ikt} + \Delta \ln P(k)_{kt} \right] \tag{13}$$

The third set of weights are shares of world GDP. As described above, these shares are consistent with the assumption of zero trade costs and no preference heterogeneity:

$$\hat{\pi}_{it}^{GDP} = \sum_{k=1}^{N} \frac{1}{2} \left[ \frac{GDP_{kt}}{GDP_t^W} + \frac{GDP_{kt-1}}{GDP_{t-1}^W} \right] \left[ \Delta \ln E_{ikt} + \Delta \ln P(k)_{kt} \right] \tag{14}$$

The ability of each of these three predictions to replicate the behavior of measured inflation is evaluated primarily by comparing their means and standard deviations with those of measured inflation. In addition, the predictions of CPI inflation are combined with data on changes in bilateral nominal exchange rates to yield predictions about bilateral real exchange rate movements:

$$\Delta \ln \widehat{RER}_{ikt} = \Delta \ln E_{ikt} + \hat{\pi}_{kt} - \hat{\pi}_{it} \tag{15}$$

The variance of these predicted real exchange rate changes is compared with the variance of actual real exchange rate changes.

### *3.1. Estimating the gravity equation*

The estimating equation is based on (7), with the restriction that $\lambda(k)_i = 1 \; \forall i, k$. It can be rewritten:

$$IM_{ikt} = \frac{EXP_{it} \cdot GDP_{kt}}{GDP_t^W} \left[ \frac{P_{it} \Pi_{kt}}{\tau_{ikt}} \right]^{\eta - 1} \tag{16}$$

where all variables are measured in a common currency. As usual in the estimation of gravity equations, it is assumed that trade costs $\tau_{ikt}$ are a multiplicative function of bilateral distance and indicator variables that are plausibly correlated with trade costs. Estimated trade costs are allowed to vary over time by having time-varying coefficients on these (fixed) gravity variables:

$$\tau_{ikt} = \prod_{m=1}^{M} \left( g_{ik}^m \right)^{\gamma_t^m}, \; g_{ik}^m = 1 \text{ if } i = k, \; g_{ik}^m \geq 1 \text{ otherwise} \tag{17}$$

Substituting in for trade costs, subsuming the price and size terms into importer-year and exporter-year fixed effects and adding an error term yields:

$$IM_{ikt} = \left[ \Theta_{it} \Phi_{kt} \prod_{m=1}^{M} \left( g_{ik}^m \right)^{\delta_t^m} \right] \upsilon_{ikt} \tag{18}$$

where $\delta_t^m = \gamma_t^m (1 - \eta)$. Note that the elasticity of substitution is not separately identified.

I estimate (18) using the Poisson pseudo-maximum likelihood approach suggested by Santos Silva and Tenreyro (2006). This estimation strategy has the advantage that zeros in the dependent variable do not have to be dropped, and size-related heteroskedasticity in the level equation is conveniently dealt with.[4] The estimating equation is:

$$IM_{ikt} = \exp\left(\theta_{it} + \phi_{kt} + \sum_{m=1}^{M} \delta_t^m \ln g_{ik}^m\right) \upsilon_{ikt} \tag{19}$$

where $\theta_{it}$ and $\phi_{kt}$ are importer-year and exporter-year fixed effects respectively. As there are no cross-equation coefficient restrictions, (19) can be estimated year-by-year. The set of observations used includes "imports" of domestic output. The resulting fitted values for bilateral imports are used to construct fitted expenditure shares using:

$$\frac{\widehat{IM_{ikt}}}{EXP_{it}} = \frac{\widehat{IM}_{ikt}}{\sum_{j=1}^{N} \widehat{IM}_{ijt}} \tag{20}$$

These shares are then used to construct $\hat{\pi}_{it}^{GRAV}$.

### *3.2. Data*

The baseline exercise uses annual data from a sample of 24 OECD countries. The sample consists of all non-Eastern Bloc members of the OECD, except Iceland and Luxembourg, which are excluded because of their size. The countries in the sample are Australia, Austria, Belgium[5], Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Korea, Mexico, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the UK and the US. The years for which data are collected are 1970-2003.

The CPI and end-of-period nominal exchange rates are from the IMF's *International Financial Statistics*. The GDP deflator and current dollar GDP, total imports and total exports are taken from the OECD's *National Accounts Database*.

Data on bilateral merchandise imports in current dollars are taken from the OECD's *Monthly Statistics of International Trade*. For Korea, Mexico and New Zealand, additional data on bilateral merchandise imports are taken from the *NBER-United Nations Trade Data* prepared by Feenstra and Lipsey. The bilateral import data are rescaled to make them comparable with the GDP data. Consistent with the model presented in the previous section, the baseline measure of imports from self is GDP less total exports.

For the purpose of estimating the gravity equation, data on variables that are correlated with trade costs are required. Bilateral distance in miles is calculated using the great circle distance algorithm provided by Gray (2001). Dummy variables indicating common language and contiguity are constructed based on the *CIA World Factbook*. Only official languages are used to determine common language. It is assumed that countries share common languages with themselves and are contiguous to themselves. Indicator variables are coded to be zero when the importer country is the same as the exporter country.

#### *3.2.1. Data problems*

There are four potentially important sources of error in matching the data with the theory. First, the bilateral trade data refer to merchandise trade only, because data on bilateral service trade going back to 1970 is not available. Implicitly, the empirical exercise assumes that the geographic pattern of trade in services is the same as the pattern of merchandise trade.

Second, imports and exports measure flows of gross output, while GDP measures flows of value added. This leads to two problems. First, expenditure shares calculated using data on bilateral imports are attached to the "wrong" GDP deflators. For example, if 50% of the value added contained in consumer goods imported into the US from Mexico is produced originally in the US, then the Mexican GDP deflator will not accurately represent the effect of these imports on US consumer prices. Second, the domestically produced share in domestic expenditure is calculated under the assumption that there is no re-exporting. With re-exporting, the measured domestic expenditure share is less than the true share, and can even fall below zero (though

[4] See Santos Silva and Tenreyro (2006) for details.
[5] Bilateral merchandise import data is for Belgium-Luxembourg, but all other data refer to Belgium alone

it does not do so in the baseline sample). The Robustness section describes an approach to this issue based on an extension of the gravity model.

Third, one would like to use data from all partner countries to construct the inflation predictions. However the relevant data for countries outside the OECD is often unavailable, particularly for the first half of the sample. In the baseline results, attention is restricted to within-sample trade, and all shares are calculated as within-sample shares. The average ratio of within-sample expenditure to total expenditure is above 90% for all countries except the Netherlands (88.5%). The effect of using a bigger sample of partner countries is addressed in the Robustness section.

Finally, a consistent implementation of the theory would require comparing the inflation predictions with inflation in the price of total expenditure rather than CPI inflation. The choice of CPI is dictated by the desirability of having a measure of inflation from a different data source than that used to construct the inflation predictions. An alternative to this choice is presented in the Robustness section.

## 4. Results

Table 1 presents summary statistics for the exchange rate and price data. For each country, there are 23 in-sample bilateral nominal exchange rates. The first column of the table reports for each country the unweighted mean of the standard deviations of the relevant 23 bilateral rates. The second column reports the standard deviation of GDP deflator inflation. The third column reports the standard deviation of CPI inflation. This table illustrates the fact that bilateral nominal exchange rates are on average much more volatile than inflation. In the extreme case of Germany, the average standard deviation of of within-sample bilateral exchange rates is more than four times the standard deviation of CPI inflation.

### *4.1. Gravity estimation*

Table 2 reports the results from estimating the gravity equation. They are typical of those in the empirical gravity literature. Bilateral imports are negatively correlated with bilateral distance, are lower from non-contiguous countries than from contiguous countries, and are lower when the partners do not share a common language than when they do. In all cases, these effects are significantly different from zero at the 5% level. Two measures of goodness of fit are reported since a standard $R^2$ cannot be calculated for the Poisson regression. The first, Fit(1), is the square of the correlation between the actual and fitted values of the dependent variable. The second, Fit(2), is the square of the correlation between actual expenditure shares and the expenditure shares predicted using the gravity equation - this measures the fit of the variables actually used in the construction of $\hat{\pi}_{it}^{GRAV}$. The correlation between actual and fitted values of the dependent variable and actual and fitted values of the desired shares is consistently high.

Given an assumption about the elasticity of substitution, the implied bilateral trade costs under the normalization that $\tau_{ii} = 1 \; \forall i$ can be calculated:

$$\hat{\tau}_{ikt} - 1 = \left[ \exp\left( \sum_{m=1}^{M} \hat{\delta}_t^m \ln g_{ik}^m \right) \right]^{\frac{1}{1-\eta}} - 1 \qquad (21)$$

Following Anderson and van Wincoop (2004) a value of 5 is chosen for the elasticity of substitution. The implied trade costs trend downwards over the sample period for all pairs. Across bilateral pairs, the maximum is on the order of 300% and the minimum around 50%. These numbers are high compared with measured trade costs for goods that are actually traded, but they are representative of estimates from the gravity literature (e.g., Hummels, 2001, and Anderson and van Wincoop, 2004). As already mentioned, they can be thought of as the import-volume-equivalent uniform bilateral trade cost, consistent with the literature on measuring the restrictiveness of trade policy. Under this interpretation, it is not surprising that they are higher than measured trade costs, since presumably the (unobservable) trade costs for goods that are not traded in equilibrium are higher than those for goods which are traded.

### *4.2. Performance of the CPI inflation predictions*

Table 3 reports the mean and standard deviation of CPI inflation and the three CPI inflation predictions. For the majority of the sample countries (19 out of 24), both $\hat{\pi}_{it}^{ACT}$ and $\hat{\pi}_{it}^{GRAV}$ do a better job than $\hat{\pi}_{it}^{GDP}$ of matching the mean of inflation. In all cases, both $\hat{\pi}_{it}^{ACT}$ and $\hat{\pi}_{it}^{GRAV}$ do a dramatically better job of matching the standard deviation of inflation. In this sample of countries, the average ratio of the standard deviation of $\hat{\pi}_{it}^{ACT}$ to the standard deviation of CPI inflation is 1.06. For $\hat{\pi}_{it}^{GRAV}$, this ratio is 1.08. Meanwhile for $\hat{\pi}_{it}^{GDP}$, it is 2.25. Figures 1 to 24 plot CPI inflation and all three predictions. Visual inspection confirms that both $\hat{\pi}_{it}^{ACT}$ and $\hat{\pi}_{it}^{GRAV}$ are much better able to match the volatility of CPI inflation than $\hat{\pi}_{it}^{GDP}$. They are also better able to match the actual path of inflation than is $\hat{\pi}_{it}^{GDP}$.

The gap between the performance of $\hat{\pi}_{it}^{ACT}$ and that of $\hat{\pi}_{it}^{GDP}$ in matching the moments of CPI inflation indicates that actual expenditure patterns can go a long way towards explaining why exchange rate volatility does not feed back into consumer prices. Meanwhile, remembering that $\hat{\pi}_{it}^{ACT}$ allows expenditure shares to differ for very general reasons, while $\hat{\pi}_{it}^{GRAV}$ imposes that they differ only because of trade costs, their very similar performance suggests that the volatility of CPI inflation is *quantitatively consistent* with an explanation based on trade costs on the order of magnitude of those reported above.

### *4.3. Bilateral exchange rate volatility*

The performance of the inflation predictions can be further explored by calculating the ratio of the standard deviation of predicted changes in bilateral real exchange rates to the standard deviation of actual changes in bilateral real exchange rates for each of the within-sample pairs. Averaging across all bilateral pairs, the ratio of the standard deviation of the prediction constructed using $\hat{\pi}_{it}^{ACT}$ to the standard deviation of actual bilateral real exchange rate changes is 0.80. For the prediction constructed using $\hat{\pi}_{it}^{GRAV}$, the ratio is 0.70. These ratios are less than one because the covariance between nominal exchange rates and predicted inflation is more negative (larger in absolute value) than the covariance between nominal exchange rates and actual inflation. For the prediction constructed using $\hat{\pi}_{it}^{GDP}$, the ratio is 1.50, driven by the very high variance of $\hat{\pi}_{it}^{GDP}$. Clearly, the trade cost hypothesis is somewhat less successful at matching bilateral exchange rate volatility than inflation volatility. It is possible that sticky prices or pricing-to-market may have a role to play here, by reducing the correlation between inflation and exchange rates. However a full exploration is left as a topic for future research.

### *4.4. The sources of predicted inflation volatility*

As mentioned above, one potential factor in explaining the low volatility of CPI inflation relative to exchange rates is the (large) size of the home share in expenditure. An additional possibility is that countries tend to have lower bilateral exchange rate volatility with important trading partners. This point is made by Broda and Romalis (2003). The inflation predictions constructed here provide an opportunity to examine the relative importance of these two mechanisms.

Predicted inflation can be decomposed into home and foreign components as follows:

$$\Delta \ln P_{it} = \underbrace{\frac{IM_{iit}}{EXP_{it}} \Delta \ln P\left(i\right)_{it}}_{\text{home component}} + \underbrace{\sum_{k \neq i}^{N} \left[ \frac{IM_{ikt}}{EXP_{it}} \left[ \Delta \ln E_{ikt} + \Delta \ln P\left(k\right)_{kt} \right] \right]}_{\text{foreign component}} \tag{22}$$

Table 4 reports summary statistics derived using this decomposition of $\hat{\pi}_{it}^{GRAV}$. In only two out of the 24 sample countries (Belgium and Ireland) does the mean of the foreign component exceed 50% of the overall mean. In only four cases (Austria, Denmark, Ireland and Switzerland) does the foreign component account for more than 50% of the variance of $\hat{\pi}_{it}^{GRAV}$. The analogous decomposition for $\hat{\pi}_{it}^{ACT}$ yields very similar results. This emphasizes the importance of domestic factors in explaining the behavior of CPI inflation.

Table 5 reports for each country the mean weight (over 1970-2003) on domestic contributions to inflation used in each of the three inflation predictions. The domestic weights reported in this table are the implied "passthrough coefficients" of exogenous changes in nominal exchange rates (or foreign inflation) into the CPI in this world with instantaneous passthrough at the dock.[6] This table illustrates that the success of $\hat{\pi}_{it}^{ACT}$ and $\hat{\pi}_{it}^{GRAV}$ in matching the relatively low volatility of CPI inflation is due in large part to the fact that both

[6] Of course, moving forward, we should expect the inflation rate of Euro zone countries in the sample to be considerably less sensitive to exchange rate volatility than is indicated by these domestic weights. In 2003, the ratio of imports from outside the Euro zone to total expenditure in the Euro zone was only 17%, implying an average Euro zone domestic weight of 83%.

predictions assign a high weight to low-volatility domestic contributions to inflation. The corresponding failure of $\hat{\pi}_{it}^{GDP}$ to match the volatility of CPI inflation is due to the fact that it assigns a high weight to high-volatility foreign contributions to inflation. This is consistent with the findings of Hau (2002) and the distribution cost literature cited in the introduction.

I also explore the role of the correlation between bilateral expenditure shares and the volatility of $\Delta \ln E_{ikt} + \Delta \ln P(k)_{kt}$ in matching the volatility of CPI inflation. I construct the standard deviation of $\Delta \ln E_{ikt} + \Delta \ln P(k)_{kt}$ over 1970-2003 for all bilateral pairs in the sample. The correlations between these standard deviations and time-series averages of the actual and gravity bilateral expenditure shares are negative, but small for all countries. For actual shares, the average correlation across all countries is $-0.03$. For gravity shares, the average correlation is $-0.02$. The quantitative contribution of these negative correlations in reducing the volatility of CPI inflation is tiny.

## 5. Robustness

Robustness of the results reported in the previous section is tested along a number of dimensions. They are in large measure confirmed by these tests.[7]

### 5.1. *A different measure of imports from self*

As already noted, the baseline approach to measuring imports from self - by subtracting exports from GDP - is correct only if all of the value added in exports is domestically produced. This measurement issue is likely to bias the results *against* finding that $\hat{\pi}_{it}^{ACT}$ or $\hat{\pi}_{it}^{GRAV}$ can match the volatility of inflation. One approach to this issue (e.g., Wei, 1996) is to calculate imports from self as gross output less exports. If gross output is not available, it can be estimated as a fixed multiple of value added. This is consistent with an extension of the baseline model (described in an appendix available on request).

Limited data on gross output is available from the OECD's *Intersectoral Database*. The average ratio across available observations is 1.98, with a standard deviation of 0.2. Based on this, I multiply GDP by 2 to obtain an estimate of gross output for all countries and years in the baseline sample. Ideally, one would like to use a deflator for gross output rather than the GDP deflator to construct the inflation contributions. Since such a deflator is not available for all the countries in the sample, the GDP deflator is used. The results from comparing the modified $\hat{\pi}_{it}^{GRAV}$ with actual inflation do not differ markedly from those in Table 3. If anything, the ability to match the actual path of CPI inflation is improved by increasing the weight on domestic output in domestic expenditure, particularly for the smaller economies. The volatility of predicted bilateral real exchange rate changes is also better able to match the volatility of actual real exchange rate changes. The average ratio of the standard deviation of changes in the real exchange rate predictions based on $\hat{\pi}_{it}^{ACT}$ and $\hat{\pi}_{it}^{GRAV}$ to the standard deviation of actual real exchange rate changes is 0.91 and 0.82 respectively, as compared with 0.80 and 0.70 in the baseline case.

### 5.2. *Expanded import sample*

In principle, the inflation predictions should be constructed using data for *all* trading partners. The fact that the baseline results use only in-sample shares could be a source of excess smoothness if within-sample bilateral exchange rates are on average less volatile than exchange rates with partners not in the sample. To test the robustness of the results to the restriction of the sample, data on the relevant variables is collected for a larger sample of 162 countries from 1970-2000. The bilateral trade data is taken from the *NBER-United Nations Trade Data* prepared by Feenstra and Lipsey. National accounts data and the CPI are from the *World Development Indicators*. Nominal exchange rates are from the IMF's *International Financial Statistics*. For many of these countries, data is available for only some of the years 1970-2000. Though improved, import coverage is still imperfect.

Because of difficulties in estimating a nonlinear gravity equation on such a large dataset, $\hat{\pi}_{it}^{ACT}$ and $\hat{\pi}_{it}^{GDP}$ but not $\hat{\pi}_{it}^{GRAV}$ are constructed. The relative performance of $\hat{\pi}_{it}^{ACT}$ and $\hat{\pi}_{it}^{GDP}$ in matching the moments of CPI inflation is very similar to those of the original predictions.

[7] Full details are not provided here but are available on request.

### *5.3. Expenditure deflator inflation*

As already noted, the use of CPI inflation rather than expenditure deflator inflation is an inconsistency in the empirical implementation of the model. When a deflator for total expenditure calculated using national accounts data is used instead of the CPI, the results are unchanged. As a further check, for 15 of the sample countries, the aggregate share of imports in private consumption (i.e. the direct import content plus the imported content of consumption of domestic output) was calculated using input-output tables from the OECD STAN database. The comparison of these shares with the shares summarized in Table 5, and their equivalents constructed using gross output rather than GDP, indicates that the first order source of error in the baseline shares is not the fact that they refer to total expenditure rather than consumption, but the fact that they do not take account of the distinction between gross output and GDP. As noted above, this biases the results *against* finding that trade costs can reconcile the volatility of CPI inflation with that of exchange rates.

## 6. Conclusion

This paper examines the degree to which trade costs can quantitatively reconcile the low volatility of consumer price inflation with the high volatility of nominal exchange rates. I present a simple multi-country model with fully flexible prices where costly trade and preference heterogeneity drive cross-country differences in expenditure patterns. In this setting consumer price inflation can be approximated as an expenditure-share-weighted average of the contributions to inflation from all sources of imports, including the home country. This observation motivates a partial equilibrium calibration exercise using data from 24 OECD countries over the period 1970-2003.

I construct "predictions" of CPI inflation using weighted averages of actual data on exchange rate changes and GDP deflator inflation. I impose three different assumptions about the determinants of differences in expenditure patterns by using three different sets of weights. Measured expenditure shares capture all possible determinants of expenditure differences. Shares constructed using the fitted values from a gravity model of trade capture that part of expenditure patterns that can be explained by correlates of trade costs. The case of zero trade costs (and no other reasons for differences in expenditure patterns) is captured by using shares of world GDP as weights. The moments of these three predictions are then compared with the moments of actual inflation.

The results of this exercise indicate that trade costs can explain both qualitatively and quantitatively the failure of exchange rate volatility to feed into inflation volatility. They are robust to a number of different variations in the empirical implementation. I explore the mechanisms underlying this success, and argue that the share of expenditure on home output is the main channel through which impact of exchange rate volatility on inflation is curtailed.

Of course the exercise in this paper takes the volatility of exchange rates as given, and in that sense, it is partial equilibrium. But by showing that a plausible combination of specialization and trade costs can explain why substantial exchange rate volatility need not affect inflation, it is made clear that the economic forces that tend to dampen exchange rate volatility are weak. This is obviously an important component of any explanation for why exchange rates are so volatile in the first place.

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**Table 1: Summary statistics for exchange rate changes and inflation**

| Country | Mean of st. dev. of bilat. ex. rate change | St. dev. of GDP deflator inflation | St. dev. of CPI inflation |
|---|---|---|---|
| Australia | 14.5 | 4.16 | 3.84 |
| Austria | 10.2 | 2.25 | 2.19 |
| Belgium | 10.3 | 2.71 | 3.00 |
| Canada | 13.4 | 3.52 | 3.18 |
| Denmark | 11.9 | 3.65 | 3.56 |
| Finland | 10.8 | 4.47 | 4.39 |
| France | 10.2 | 3.87 | 3.96 |
| Germany | 10.3 | 1.95 | 1.92 |
| Greece | 11.2 | 6.22 | 6.41 |
| Ireland | 11.0 | 5.26 | 5.56 |
| Italy | 11.5 | 5.53 | 5.37 |
| Japan | 14.5 | 4.17 | 4.48 |
| Korea | 18.4 | 7.22 | 6.47 |
| Mexico | 35.6 | 19.94 | 21.26 |
| Netherlands | 10.1 | 2.80 | 2.64 |
| New Zealand | 12.8 | 5.68 | 5.28 |
| Norway | 10.7 | 3.90 | 3.21 |
| Portugal | 12.5 | 6.70 | 7.45 |
| Spain | 11.4 | 4.96 | 5.28 |
| Sweden | 11.2 | 3.56 | 3.65 |
| Switzerland | 11.9 | 2.58 | 2.47 |
| Turkey | 26.3 | 16.26 | 17.42 |
| UK | 12.7 | 5.14 | 5.06 |
| USA | 13.6 | 2.41 | 2.84 |

Data is annual. Sample is 1971-2003. Column 1 reports the mean of the standard deviations of log changes in the 23 in-sample bilateral exchange rates for the country in question. Columns 2 and 3 report standard deviations of GDP deflator inflation and CPI inflation respectively. Details of data sources and construction are in the text.

**Table 2: Gravity equation estimates**

| Year | Ln(1+dist) | | Not contig. | | No comm. lang. | | Fit(1) | Fit(2) | N |
|---|---|---|---|---|---|---|---|---|---|
| 1970 | -0.47 | (0.03)** | -0.70 | (0.15)** | -0.69 | (0.13)** | 1.00 | 0.98 | 576 |
| 1971 | -0.48 | (0.03)** | -0.73 | (0.15)** | -0.64 | (0.14)** | 1.00 | 0.98 | 576 |
| 1972 | -0.48 | (0.03)** | -0.76 | (0.15)** | -0.61 | (0.14)** | 1.00 | 0.98 | 576 |
| 1973 | -0.47 | (0.03)** | -0.72 | (0.15)** | -0.57 | (0.14)** | 1.00 | 0.98 | 576 |
| 1974 | -0.46 | (0.03)** | -0.75 | (0.15)** | -0.53 | (0.14)** | 1.00 | 0.97 | 576 |
| 1975 | -0.48 | (0.03)** | -0.74 | (0.15)** | -0.52 | (0.16)** | 1.00 | 0.98 | 576 |
| 1976 | -0.47 | (0.03)** | -0.78 | (0.15)** | -0.50 | (0.15)** | 1.00 | 0.97 | 576 |
| 1977 | -0.47 | (0.03)** | -0.78 | (0.14)** | -0.50 | (0.15)** | 1.00 | 0.98 | 576 |
| 1978 | -0.47 | (0.03)** | -0.76 | (0.14)** | -0.49 | (0.15)** | 1.00 | 0.98 | 576 |
| 1979 | -0.46 | (0.03)** | -0.76 | (0.14)** | -0.46 | (0.15)** | 1.00 | 0.97 | 576 |
| 1980 | -0.46 | (0.03)** | -0.75 | (0.13)** | -0.45 | (0.14)** | 1.00 | 0.97 | 576 |
| 1981 | -0.45 | (0.03)** | -0.77 | (0.13)** | -0.47 | (0.13)** | 1.00 | 0.97 | 576 |
| 1982 | -0.46 | (0.03)** | -0.76 | (0.13)** | -0.41 | (0.13)** | 1.00 | 0.97 | 576 |
| 1983 | -0.45 | (0.03)** | -0.77 | (0.13)** | -0.40 | (0.13)* | 1.00 | 0.97 | 576 |
| 1984 | -0.43 | (0.03)** | -0.77 | (0.14)** | -0.47 | (0.14)** | 1.00 | 0.96 | 576 |
| 1985 | -0.43 | (0.03)** | -0.77 | (0.14)** | -0.45 | (0.14)** | 1.00 | 0.96 | 576 |
| 1986 | -0.45 | (0.03)** | -0.75 | (0.13)** | -0.42 | (0.14)** | 1.00 | 0.97 | 576 |
| 1987 | -0.46 | (0.03)** | -0.72 | (0.13)** | -0.40 | (0.14)** | 1.00 | 0.97 | 576 |
| 1988 | -0.45 | (0.03)** | -0.74 | (0.13)** | -0.40 | (0.13)** | 1.00 | 0.97 | 576 |
| 1989 | -0.44 | (0.03)** | -0.77 | (0.12)** | -0.37 | (0.13)** | 1.00 | 0.97 | 576 |
| 1990 | -0.45 | (0.03)** | -0.75 | (0.12)** | -0.37 | (0.13)** | 1.00 | 0.97 | 576 |
| 1991 | -0.45 | (0.03)** | -0.79 | (0.12)** | -0.33 | (0.13)* | 1.00 | 0.97 | 576 |
| 1992 | -0.45 | (0.03)** | -0.79 | (0.12)** | -0.37 | (0.14)** | 1.00 | 0.97 | 576 |
| 1993 | -0.45 | (0.03)** | -0.78 | (0.14)** | -0.47 | (0.15)** | 1.00 | 0.97 | 576 |
| 1994 | -0.43 | (0.03)** | -0.80 | (0.14)** | -0.46 | (0.15)** | 1.00 | 0.97 | 576 |
| 1995 | -0.43 | (0.03)** | -0.82 | (0.15)** | -0.41 | (0.16)** | 1.00 | 0.97 | 576 |
| 1996 | -0.42 | (0.03)** | -0.85 | (0.15)** | -0.41 | (0.16)* | 1.00 | 0.96 | 576 |
| 1997 | -0.40 | (0.03)** | -0.91 | (0.16)** | -0.41 | (0.15)** | 1.00 | 0.96 | 576 |
| 1998 | -0.40 | (0.03)** | -0.94 | (0.15)** | -0.40 | (0.15)** | 1.00 | 0.95 | 576 |
| 1999 | -0.39 | (0.03)** | -0.98 | (0.16)** | -0.42 | (0.15)** | 1.00 | 0.95 | 576 |
| 2000 | -0.37 | (0.03)** | -1.06 | (0.15)** | -0.40 | (0.15)** | 1.00 | 0.93 | 576 |
| 2001 | -0.38 | (0.03)** | -1.03 | (0.14)** | -0.39 | (0.14)** | 1.00 | 0.94 | 576 |
| 2002 | -0.39 | (0.03)** | -1.00 | (0.14)** | -0.37 | (0.14)** | 1.00 | 0.94 | 576 |
| 2003 | -0.41 | (0.03)** | -0.98 | (0.14)** | -0.34 | (0.14)* | 1.00 | 0.96 | 576 |

Dep. var. is bilateral imports in current US$. Imports from self are included. Estimation method is pseudo-maximum likelihood (Poisson regression). Importer and exporter fixed effects are included. Robust standard errors in parentheses; * significant at 5%; ** significant at 1%.

**Table 3: Moments of CPI inflation and inflation predictions**

| | Mean | St.dev. | Mean | St.dev. | Mean | St.dev. | Mean | St.dev. |
|---|---|---|---|---|---|---|---|---|
| | Australia | | Austria | | Belgium | | Canada | |
| CPI inflation | 6.33 | 3.90 | 3.76 | 2.23 | 4.29 | 3.05 | 4.91 | 3.23 |
| Actual share | 6.04 | 4.46 | 3.38 | 2.20 | 4.15 | 3.64 | 4.75 | 3.62 |
| Gravity share | 6.00 | 4.43 | 3.29 | 2.51 | 4.09 | 3.32 | 4.78 | 3.53 |
| GDP share | 5.93 | 10.36 | 2.23 | 7.63 | 3.47 | 8.47 | 5.49 | 7.58 |
| | Denmark | | Finland | | France | | Germany | |
| CPI inflation | 5.43 | 3.62 | 5.91 | 4.46 | 5.33 | 4.02 | 3.14 | 1.95 |
| Actual share | 5.35 | 4.40 | 5.84 | 4.25 | 5.10 | 4.06 | 2.96 | 2.03 |
| Gravity share | 5.29 | 4.77 | 5.79 | 4.39 | 5.10 | 4.06 | 2.96 | 1.99 |
| GDP share | 4.39 | 8.04 | 5.12 | 8.39 | 4.57 | 8.38 | 2.25 | 7.91 |
| | Greece | | Ireland | | Italy | | Japan | |
| CPI inflation | 12.31 | 6.50 | 7.27 | 5.64 | 8.06 | 5.46 | 3.41 | 4.55 |
| Actual share | 12.20 | 6.65 | 6.75 | 6.62 | 8.29 | 5.82 | 2.59 | 4.13 |
| Gravity share | 12.02 | 6.78 | 6.79 | 6.28 | 8.33 | 5.84 | 2.73 | 4.16 |
| GDP share | 11.23 | 9.43 | 5.95 | 9.17 | 7.42 | 10.02 | 1.22 | 9.25 |
| | Korea | | Mexico | | Netherlands | | New Zealand | |
| CPI inflation | 8.21 | 6.57 | 25.40 | 21.59 | 3.94 | 2.68 | 7.40 | 5.37 |
| Actual share | 9.52 | 8.37 | 24.28 | 20.80 | 3.48 | 2.95 | 7.06 | 5.94 |
| Gravity share | 9.66 | 7.77 | 24.42 | 21.27 | 3.55 | 2.74 | 6.97 | 6.19 |
| GDP share | 8.67 | 15.20 | 24.66 | 33.44 | 2.64 | 7.80 | 6.36 | 10.55 |
| | Norway | | Portugal | | Spain | | Sweden | |
| CPI inflation | 5.57 | 3.26 | 11.61 | 7.56 | 8.45 | 5.36 | 5.77 | 3.71 |
| Actual share | 5.15 | 3.57 | 10.81 | 7.53 | 8.10 | 5.31 | 5.95 | 3.93 |
| Gravity share | 5.05 | 3.64 | 10.72 | 8.08 | 8.05 | 5.35 | 5.93 | 3.90 |
| GDP share | 4.57 | 7.00 | 9.80 | 11.65 | 6.64 | 10.11 | 5.74 | 9.00 |
| | Switzerland | | Turkey | | UK | | USA | |
| CPI inflation | 3.13 | 2.51 | 39.85 | 17.69 | 6.91 | 5.13 | 4.71 | 2.89 |
| Actual share | 2.68 | 2.74 | 38.43 | 18.13 | 6.57 | 5.28 | 4.07 | 2.53 |
| Gravity share | 2.39 | 3.51 | 38.59 | 18.75 | 6.64 | 5.19 | 4.02 | 2.50 |
| GDP share | 1.09 | 8.52 | 38.44 | 25.21 | 5.63 | 9.41 | 4.77 | 6.21 |

Data is annual. Sample period is 1971-2003. Inflation rates are calculated as log changes. Predictions of inflation are weighted averages of log changes in bilateral exchange rates and the GDP deflator in all 24 sample countries. Actual share prediction is constructed using measured in-sample expenditure shares. Gravity share prediction is constructed using in-sample expenditure shares forecast by estimating a gravity equation. GDP share prediction is constructed using in-sample GDP shares. For details on data sources and construction, see text.

**Table 4: Decomposition of gravity inflation prediction**

| | Mean | | | Variance | | | |
|---|---|---|---|---|---|---|---|
| | Total | Shares | | Total | Shares | | |
| | | Home | Foreign | | Home | Cov. | Foreign |
| Australia | 6 | 0.85 | 0.16 | 19 | 0.75 | 0.09 | 0.16 |
| Austria | 3 | 0.52 | 0.49 | 6 | 0.23 | 0.22 | 0.55 |
| Belgium | 4 | 0.51 | 0.50 | 11 | 0.25 | 0.29 | 0.46 |
| Canada | 5 | 0.78 | 0.23 | 12 | 0.74 | 0.07 | 0.18 |
| Denmark | 5 | 0.60 | 0.41 | 23 | 0.25 | 0.22 | 0.53 |
| Finland | 6 | 0.64 | 0.37 | 19 | 0.47 | 0.21 | 0.31 |
| France | 5 | 0.79 | 0.21 | 16 | 0.65 | 0.29 | 0.07 |
| Germany | 3 | 0.84 | 0.17 | 4 | 0.78 | 0.09 | 0.13 |
| Greece | 12 | 0.60 | 0.40 | 43 | 0.36 | 0.39 | 0.25 |
| Ireland | 7 | 0.38 | 0.63 | 39 | 0.10 | 0.33 | 0.57 |
| Italy | 9 | 0.83 | 0.17 | 33 | 0.67 | 0.27 | 0.07 |
| Japan | 3 | 0.97 | 0.03 | 18 | 0.94 | 0.05 | 0.01 |
| Korea | 10 | 0.77 | 0.24 | 59 | 0.50 | 0.26 | 0.25 |
| Mexico | 25 | 0.77 | 0.23 | 447 | 0.53 | 0.34 | 0.13 |
| Netherlands | 4 | 0.68 | 0.33 | 7 | 0.57 | 0.21 | 0.22 |
| New Zealand | 7 | 0.69 | 0.33 | 38 | 0.44 | 0.23 | 0.34 |
| Norway | 5 | 0.59 | 0.42 | 13 | 0.43 | 0.17 | 0.38 |
| Portugal | 11 | 0.53 | 0.48 | 64 | 0.19 | 0.44 | 0.38 |
| Spain | 8 | 0.79 | 0.21 | 27 | 0.60 | 0.29 | 0.12 |
| Sweden | 6 | 0.70 | 0.31 | 15 | 0.52 | 0.19 | 0.29 |
| Switzerland | 2 | 0.60 | 0.41 | 13 | 0.14 | 0.06 | 0.82 |
| Turkey | 40 | 0.68 | 0.33 | 315 | 0.36 | 0.42 | 0.23 |
| UK | 7 | 0.84 | 0.17 | 26 | 0.72 | 0.17 | 0.11 |
| USA | 4 | 0.94 | 0.06 | 6 | 0.95 | 0.02 | 0.03 |

Gravity share inflation prediction can be expressed as the sum of home and foreign contributions to inflation. Columns 1, 2 and 3 report the mean of the gravity prediction and the home and foreign components. Columns 4, 5, 6 and 7 decompose the the variance of the gravity prediction into the parts attributable to home, foreign and the covariance of home and foreign contributions. Sample period is 1971-2003.

**Table 5: Home expenditure shares**

| | Mean over 1970-2003 | | |
|---|---|---|---|
| | Actual | Gravity | GDP |
| Australia | 0.82 | 0.84 | 0.02 |
| Austria | 0.65 | 0.46 | 0.01 |
| Belgium | 0.34 | 0.49 | 0.01 |
| Canada | 0.71 | 0.79 | 0.03 |
| Denmark | 0.67 | 0.56 | 0.01 |
| Finland | 0.71 | 0.60 | 0.01 |
| France | 0.78 | 0.79 | 0.07 |
| Germany | 0.76 | 0.83 | 0.09 |
| Greece | 0.76 | 0.58 | 0.01 |
| Ireland | 0.40 | 0.36 | 0.00 |
| Italy | 0.78 | 0.81 | 0.05 |
| Japan | 0.90 | 0.96 | 0.16 |
| Korea | 0.68 | 0.77 | 0.01 |
| Mexico | 0.81 | 0.77 | 0.02 |
| Netherlands | 0.47 | 0.64 | 0.02 |
| New Zealand | 0.71 | 0.65 | 0.00 |
| Norway | 0.64 | 0.59 | 0.01 |
| Portugal | 0.68 | 0.51 | 0.00 |
| Spain | 0.80 | 0.75 | 0.02 |
| Sweden | 0.68 | 0.70 | 0.01 |
| Switzerland | 0.66 | 0.45 | 0.01 |
| Turkey | 0.83 | 0.70 | 0.01 |
| UK | 0.73 | 0.81 | 0.05 |
| USA | 0.90 | 0.95 | 0.37 |

Data is annual. Sample is 1970-2003. Actual home share in home expenditure is calculated by subtracting exports from GDP and dividing by GDP less exports plus imports. Gravity home share is home expenditure share predicted by the gravity equation. GDP share is country's share in world GDP.

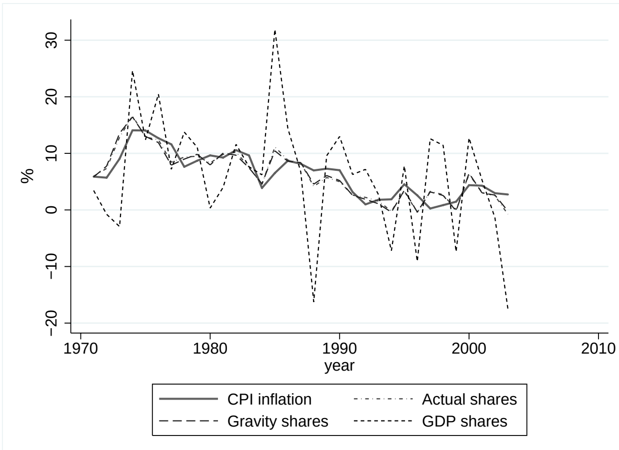


Figure 1: Australia

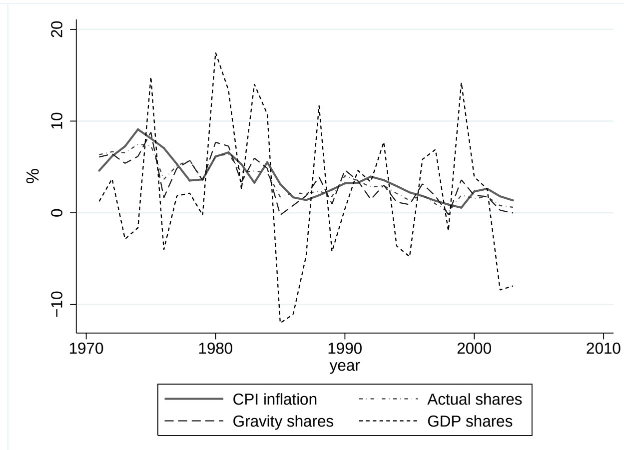


Figure 2: Austria

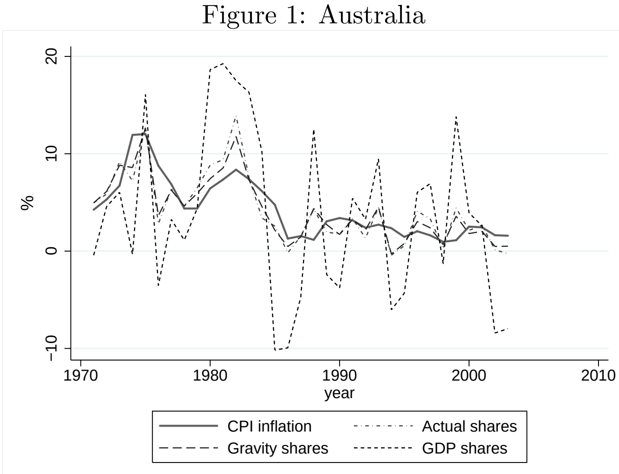


Figure 3: Belgium

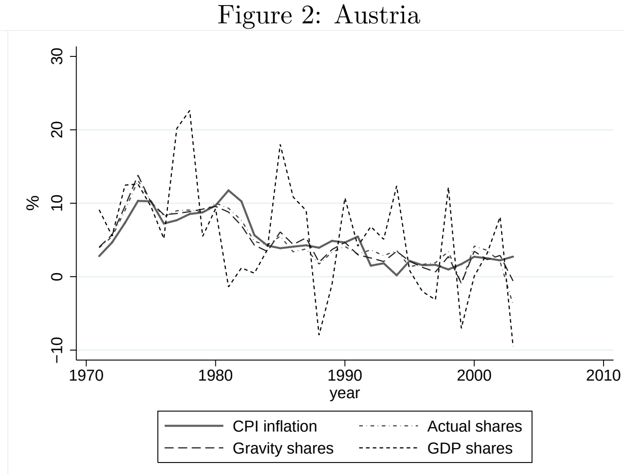


Figure 4: Canada

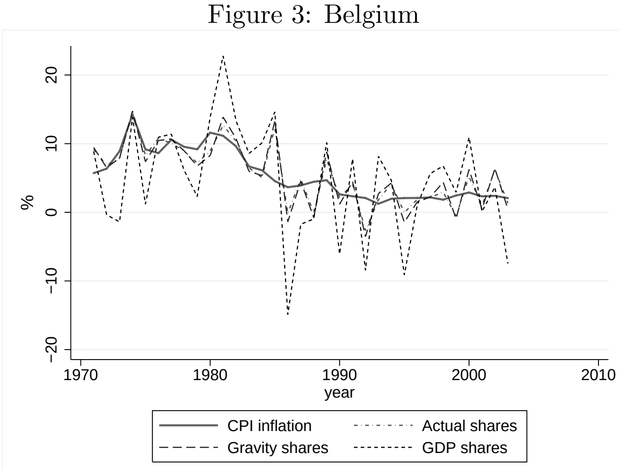


Figure 5: Denmark

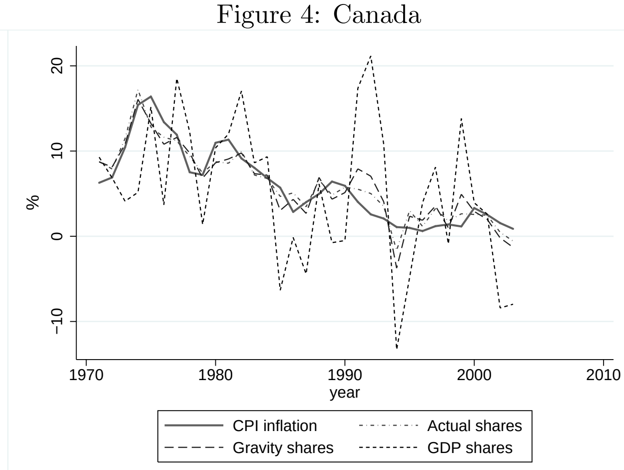


Figure 6: Finland

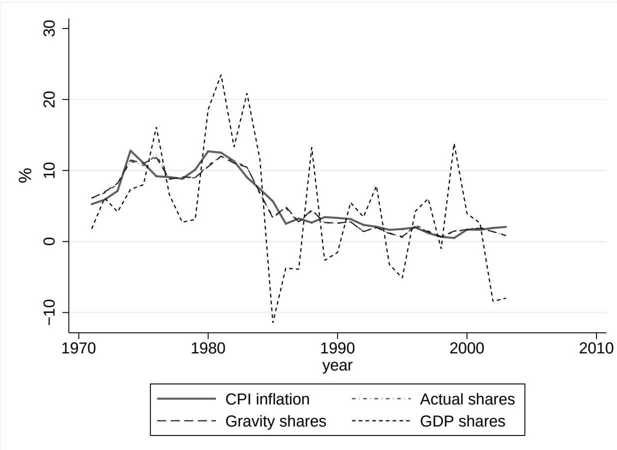


Figure 7: France

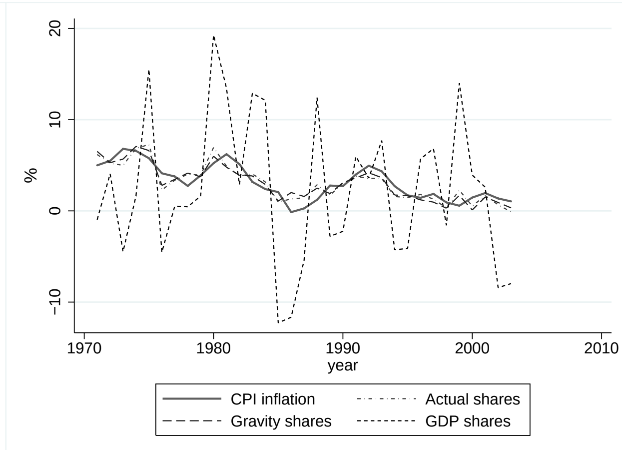


Figure 8: Germany

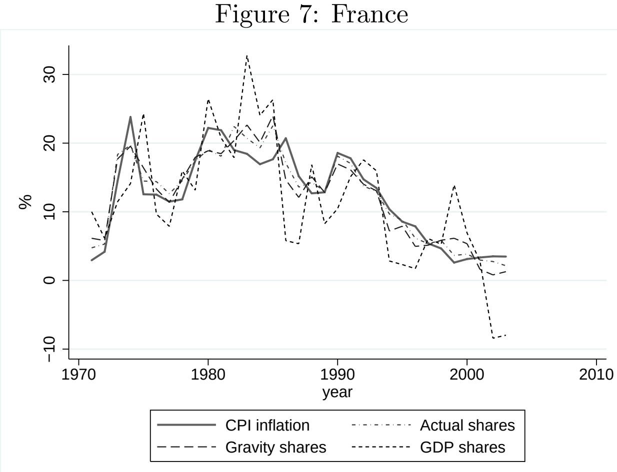


Figure 9: Greece

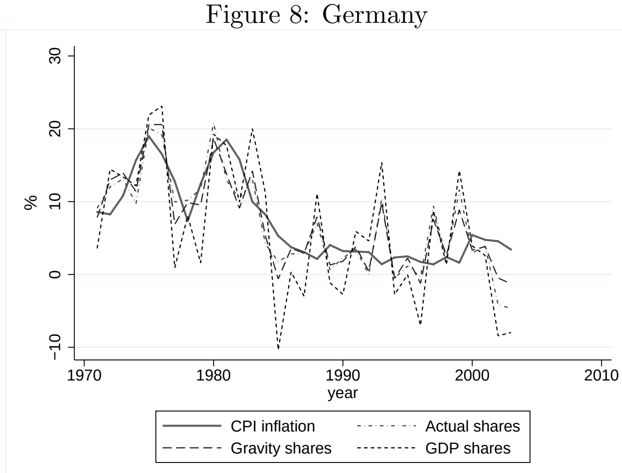


Figure 10: Ireland

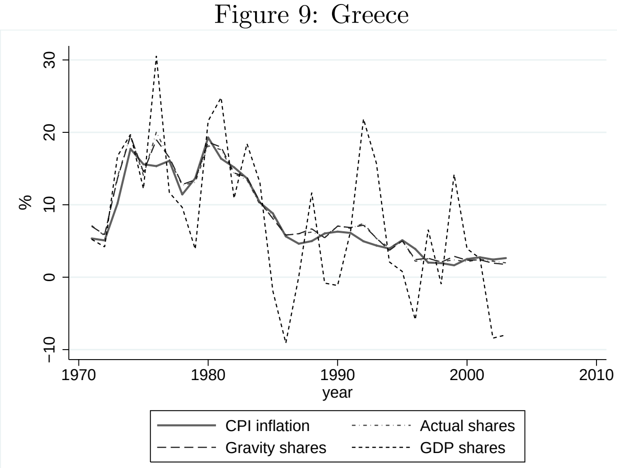


Figure 11: Italy

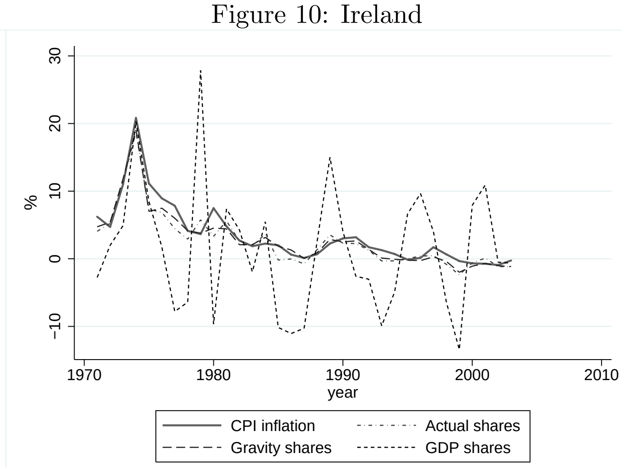


Figure 12: Japan

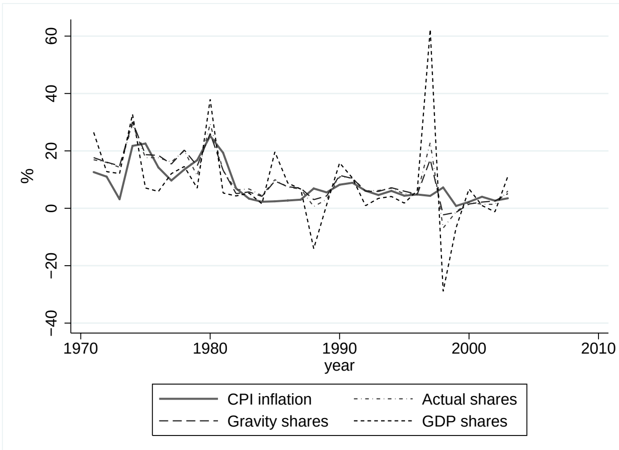


Figure 13: Korea

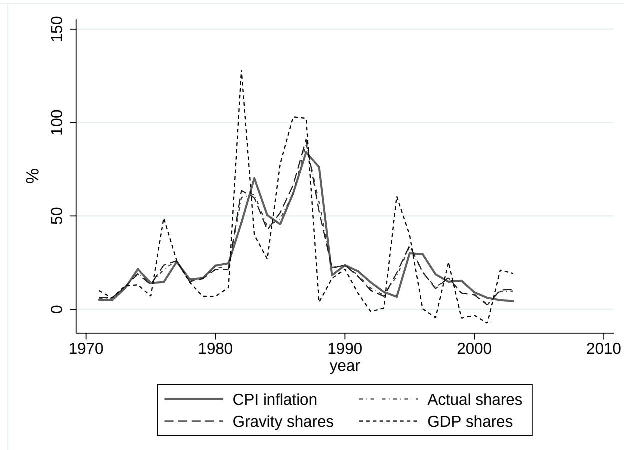


Figure 14: Mexico

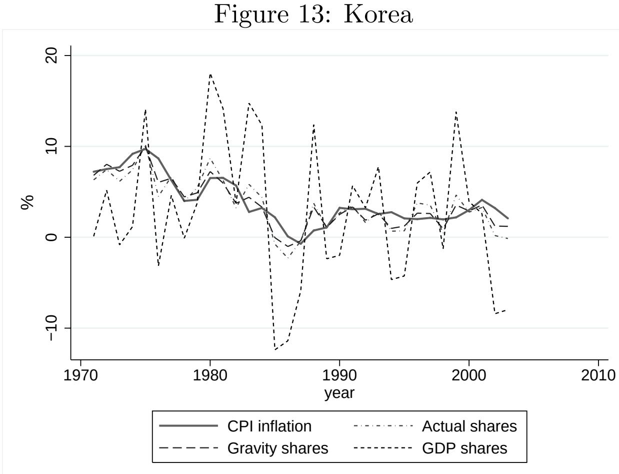


Figure 15: Netherlands

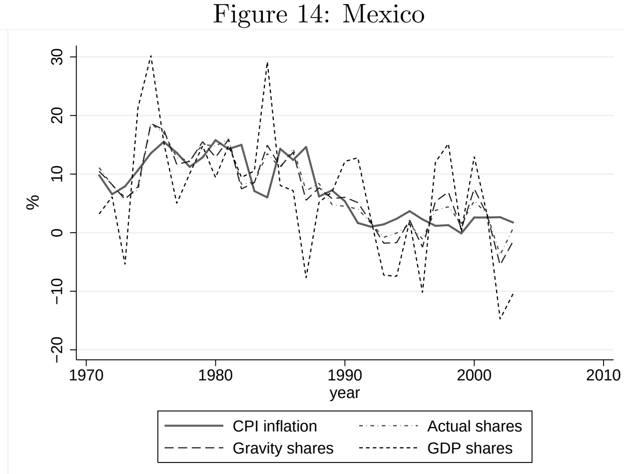


Figure 16: New Zealand

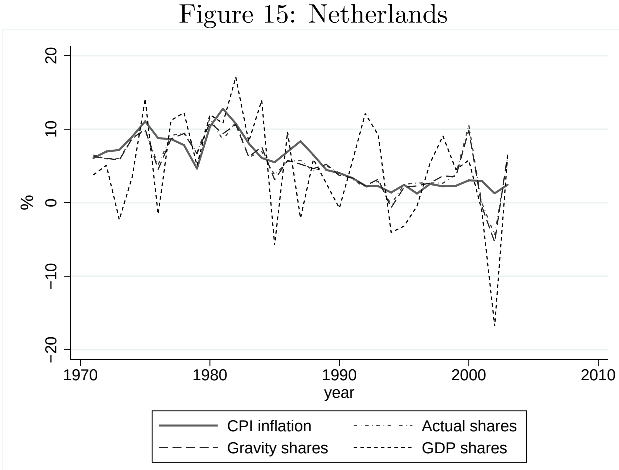


Figure 17: Norway

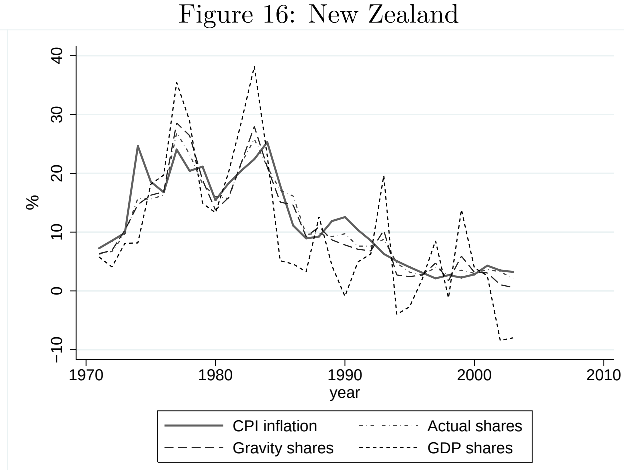


Figure 18: Portugal

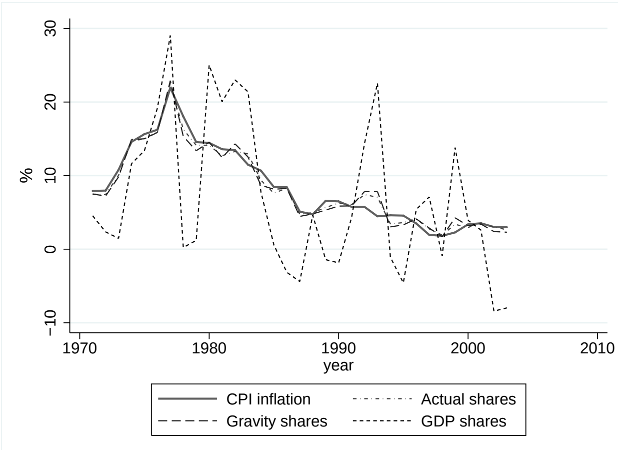


Figure 19: Spain

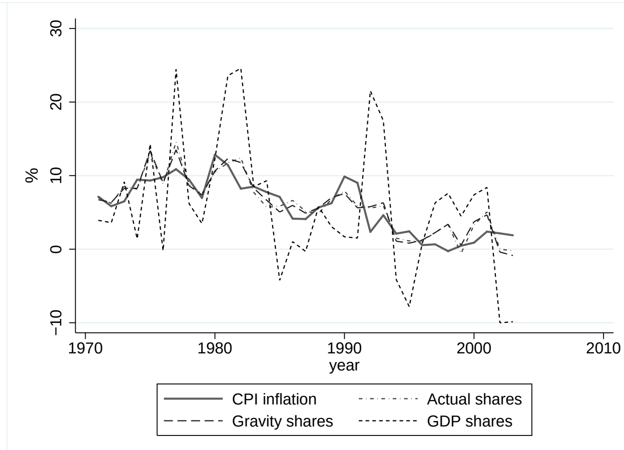


Figure 20: Sweden

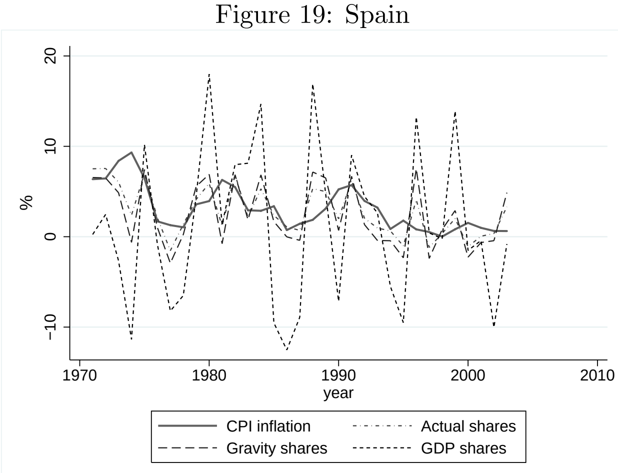


Figure 21: Switzerland

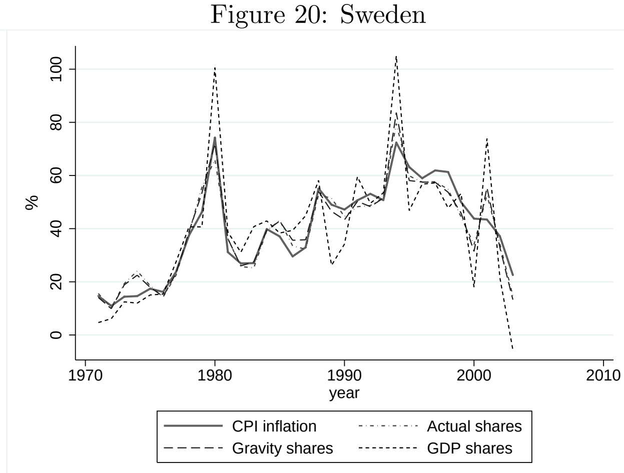


Figure 22: Turkey

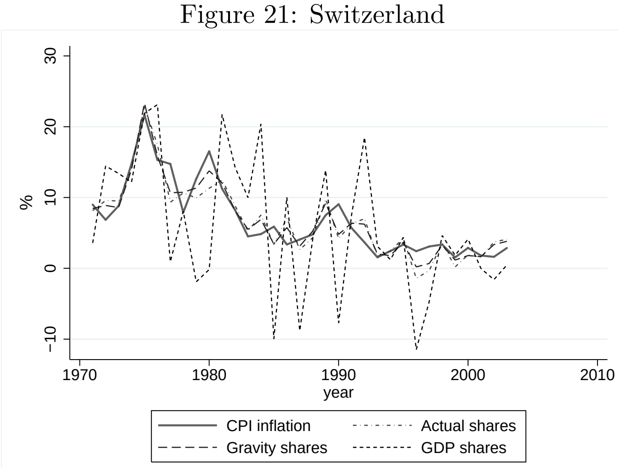


Figure 23: UK

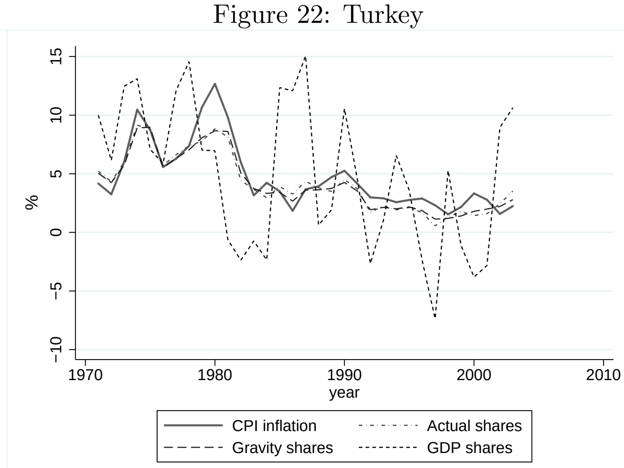


Figure 24: USA