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Relative Prices and Sectoral Productivity

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Abstract

The relative price of services rises with development. A standard interpretation of this fact is that productivity differences across countries are larger in manufacturing than in services. The service sector comprises heterogeneous categories. We document that many disaggregated service categories—such as transportation, communication, and finance—feature a negative income elasticity of relative prices, whereas the relative price of aggregate services is mostly driven by large expenditure categories in housing, collective government, and health that feature a positive income elasticity of relative prices. We also document a substantial reallocation of expenditures in services from categories with positive income elasticities (traditional services) to categories with negative elasticities (non-traditional services) as income rises. Using an otherwise standard multi-sector development accounting framework extended to include an input-output structure, we find that the cross-country income elasticity of sectoral productivity is large in non-traditional services (1.15), smaller in manufacturing (1.05) and much smaller in traditional services (0.67). Eliminating cross-country productivity differences in non-traditional services reduces aggregate income disparity by 58 percent, a 7.9-fold reduction in aggregate productivity differences. We also find that the heterogeneity between traditional and non-traditional services has a substantial impact on aggregate productivity and that the input-output structure is important in this assessment.

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1 Introduction

A well-known fact in the development literature is that the expenditure price of services relative to the price of GDP rises systematically with income per capita.[1] The standard interpretation of the rising relative price of services with development is that cross-country differences in productivity are larger in manufacturing than in services (Kravis et al., 1983; Hsieh and Klenow, 2007; Herrendorf and Valentinyi, 2012). This sectoral characterization of productivity differences is important for at least two reasons. First, it identifies "problem sectors" in accounting for the large aggregate income differences across countries. Second, it indicates that the process of structural transformation—the reallocation of resources across sectors in development—can be helpful in mitigating aggregate productivity differences since the process involves a reallocation of factors towards the service sector as income grows.

The standard interpretation, however, has two important limitations that our paper addresses. First, it assumes that the service sector is homogeneous, while, in reality, this sector includes very heterogenous service industries. The heterogeneity in the service sector has been recognized in the literature. For instance, Kuznets (1957) emphasizes heterogeneity in services in addressing cross-country differences in the income share of services. Similarly, and in contrast to Baumol (1967)'s seminal work, Baumol et al. (1985) conclude that "The service sector happens to contain some of the economy's most progressive activities as well as its most stagnant."[2] In particular, there is mounting evidence of a wide range of behavior of productivity growth and relative prices across different service industries and countries. For instance, Baumol et al. (1985) document growth rates of productivity for specific service industries that are as large as those in manufacturing in U.S. post-war data and emphasize the importance of these differences within services.[3] We use a comprehensive cross-country

[1] The data for individual countries also reveals that the relative price of services rises over time (Duarte and Restuccia, 2010).

[2] Jorgenson and Timmer (2011) emphasize the importance of heterogeneity in the service sector for a modern analysis of structural change.

[3] Baily and Solow (2001) also document cross-country differences in labor productivity for specific service

dataset of expenditure prices and show that many service industries have a falling relative price with income, in sharp contrast with the behavior of the relative price of aggregate services. We argue that this heterogeneity is important in understanding sectoral productivity differences across countries. Second, the standard interpretation measures sectoral productivity using expenditures in final goods and services rather than sectoral value-added. Therefore, these measures relate to a composite of sectoral productivities that depend on the input-output structure of the economy. The potential pitfall of using expenditure data to infer sectoral productivity differences across countries has been emphasized in the literature (e.g. Heston and Summers, 1996, p. 22). We derive sectoral productivity implications by extending an otherwise standard multi-sector development accounting framework to incorporate input-output linkages across sectors.

We use detailed price data from the International Comparisons Program (ICP). The ICP dataset provides price and nominal expenditure data for 129 expenditure categories that aggregate up to gross domestic product (GDP) for 130 countries in 2005. In our data, the income elasticity of the relative price of aggregate services is 0.14, so the relative price of services rises with development. However, across disaggregated categories of services, we find substantial heterogeneity in the income elasticity of relative prices, with elasticities ranging between very negative (-0.6) and very positive (0.4) numbers. In addition, many service categories feature a negative income elasticity, such as transportation, communication, and finance/insurance; whereas the relative price of aggregate services is mostly driven by large expenditure categories that feature a positive income elasticity, such as housing, collective government, and health. In contrast, the range of income elasticities of relative prices among individual categories in the manufacturing sector lies mostly in the negative range between -0.37 and 0.05. Indeed, we find a larger dispersion of elasticities across categories in services

industries that are as large as those in manufacturing. Jones et al. (1990) explore the role of a sub-set of services (for which the relative price is declining) in the international fragmentation of production. Inklaar and Timmer (2014) emphasize rising output prices of non-market services in accounting for the Penn effect—the rising price of income relative to the exchange rate with development.

(a standard deviation of 0.20) compared to manufacturing (0.09), including when weighting categories by world expenditure shares. We also show that there is substantial reallocation of expenditures within services with development, with expenditures moving from service categories featuring a rising relative price to service categories featuring a falling relative price.

We assess the productivity implications of heterogeneity in the service sector by closely following the literature and using a development accounting framework which imposes minimal structure. The accounting framework uses expenditure and price data from the ICP. While this approach is still subject to the limitation discussed earlier on the use of expenditure data, it highlights the importance of heterogeneity in services using the same methodology and data as the existing literature. We derive a simple mapping between the income elasticities of sectoral productivity and relative prices for any individual expenditure category. In particular, the income elasticity of sectoral productivity is one minus the income elasticity of the relative price. This implies that productivity variation across countries is low for those services that feature a rising relative price with development, whereas the productivity variation is high for services whose relative price declines with development, and this productivity variation is larger than that of the manufacturing sector for some service categories such as transportation, communication, among others. The heterogeneity in productivity variation within services is substantial. For instance, consider two categories of services with income elasticities of relative prices of -0.2 and 0.2, well within the range of elasticities in the data. The income elasticities of sectoral productivity are 1.2 and 0.8, and considering that the ratio of GDP per capita between the top and bottom deciles of the income distribution is a factor of 49-fold, these elasticities imply that the factor difference in sectoral productivity between these countries are 107.5 and 22.6-fold in each case. These are striking differences in sectoral productivity implied by the income elasticities of relative prices.

To address the issue of intermediate inputs, we extend the accounting framework following Ngai and Samaniego (2009) to include input-output linkages across sectors and derive sectoral productivity implications from expenditure data. We show that our simple mapping of relative expenditure prices to sectoral productivity holds up to an adjustment factor that depends on the input-output structure. To implement this extension quantitatively and to provide a tractable characterization of heterogeneity in the service sector we aggregate service categories into two broad categories: traditional services which includes all individual service categories whose relative price increases systematically with income and non-traditional services which includes all individual service categories with a relative price that falls systematically with income. Our aggregation follows the spirit of Baumol (1967) in characterizing some industries as stagnant with less scope for productivity growth (traditional) relative to other more dynamic sectors in the economy (non-traditional). We restrict the input-output parameters using data from the World Input-Output Database (WIOD) and find that accounting for input-output linkages reduces the disparity of productivity in traditional services and, less so, in manufacturing; and increases the disparity in non-traditional services. The income elasticities of sectoral productivity are 1.05, 0.67, and 1.15 for manufacturing, traditional, and non-traditional services compared to 1.07, 0.79, and 1.13 abstracting from intermediate inputs. The ratios of sectoral productivities between the top and bottom deciles of countries in the income distribution are 66-fold in manufacturing, 12.5-fold in traditional services, and 81.2-fold in non-traditional services (compared to 68.8, 21.1, and 75.5-fold without intermediate inputs).

Because the development accounting is silent about the forces that drive reallocation across sectors and in order to assess the aggregate implications of heterogeneity in the service sector, we develop a multi-sector model building on Duarte and Restuccia (2010) and Ngai and Samaniego (2009). The model includes manufacturing, traditional services, and non-traditional services; and it features an input-output structure. We calibrate the model to U.S. data and the parameters of the model are chosen so that the model matches the real consumptions and relative price data from the ICP data as well as intermediate input shares from the WIOD. We use the model to measure sectoral productivity differences across countries and perform counterfactual analysis. The model delivers productivity implications that are very close to the development accounting and, in addition, generates the broad patterns of consumption expenditure shares in the cross-country data.

We assess the aggregate implications of sectoral productivity differences across countries by conducting a series of counterfactuals where we set, for each sector at a time, the productivity level in all countries to the level in the United States. Eliminating cross-country productivity differences in non-traditional services reduces aggregate income disparity substantially by 58 percent (a 7.9-fold reduction), whereas eliminating productivity differences in traditional services reduces income disparity by 43 percent (a 4.7-fold reduction) and in manufacturing by 30 percent (a 2.9-fold reduction). We also assess the aggregate implications of heterogeneity in services by setting the productivity in non-traditional services to that of traditional services in each country. Eliminating heterogeneity in services has substantial aggregate implications, for instance, the disparity in aggregate productivity between the top and bottom deciles of countries in the income distribution would fall to 22.1-fold from 35.8-fold in the data. This is a 14 percent reduction in income disparity, which represents about half of the reduction from eliminating the cross-country productivity differences in manufacturing. We find that the input-output structure is essential in understanding the role of this heterogeneity as non-traditional services are an important input in manufacturing production.

Our paper relates to a growing quantitative literature on the role of services in the economy. Buera and Kaboski (2012) study the interaction between growth in skill-intensive services and the decision between home and market provision of services. Ngai and Pissarides (2008) and Rogerson (2008) emphasize the importance of home-produced services for the trends in hours and the allocation of employment across market sectors. Our paper also relates to a literature emphasizing the role of input-output structure of the economy such as Jones

(2011) and Herrendorf et al. (2013). Jones (2011) focuses on the role of intermediate inputs for aggregate productivity implications whereas our study focuses on the sectoral productivity implications. Herrendorf et al. (2013) assess the relative importance of two standard mechanisms in explaining the structural transformation. They find that the preference specification (and mechanism) that can account for the U.S. data depends on whether the analysis uses value-added data or expenditure data. The input-output structure of the United States reconciles the two views, which highlights the importance of the input-output structure. Our analysis, instead, focuses on the role of intermediate inputs and the input-output structure for cross-country implications across sectors.

The paper is organized as follows. In the next section, we document a set of facts about disaggregate prices and expenditure patterns from the ICP data. Section 3 derives the productivity implications from relative price data using a multi-sector development accounting framework extended to include input-output linkages across sectors. In Section 4, we develop a model of structural transformation that features an input-output structure to assess the aggregate implications of sectoral productivity differences across countries and heterogeneity in services. We conclude in Section 5.

2 Facts

We document facts on the relative price and expenditure share of services and services subcategories. Our main focus is on the price and expenditure data from the International Comparisons Program (ICP). These data, which we describe in more detail below, are a cross-section for a large number of countries in 2005. We also report facts for the United States from 1950 to 2015. Our analysis in Section 3 uses data from the World Input-Output Database (WIOD) but we describe these data and the associated facts in that section.

2.1 Cross-Country Data

We use detailed price and expenditure data from the ICP for 2005. We also verify our main empirical findings with the data for 2011. The ICP data are the basis for the construction of the widely-used Penn World Table (PWT) where comparable measures of gross domestic product are available for a large number of countries and years. The ICP data report information on 129 expenditure categories that aggregate up to GDP. The dataset contains information on price indices and nominal expenditures (in units of domestic prices) for individual expenditure categories. From these data, nominal expenditures, real expenditures (in units of an average international price which is common across countries), and prices can be constructed for arbitrary aggregates such as consumption, investment, tradables, services, among others. We note that in order to aggregate individual categories we use the Geary-Khamis method which produces additive results, an essential feature for calculating shares in our analysis. The data covers 146 countries. We restrict our sample of countries to those with more than 1 million inhabitants, leaving 130 countries. See appendix A.1 for more details.

Aggregate services We start by constructing an aggregate category of services from the individual expenditure categories in the ICP data. We document the behavior of the relative price of services and the expenditure share of services (nominal and real) across countries. A summary of the data is reported in Table 1.

The price of aggregate services relative to that of GDP increases with income per capita. That is, the relative price of services is higher in rich countries compared to poor countries. We report the relative price of services (relative to that of the United States) against GDP per capita across countries in Figure 1, top panel. On average, the richest 10 percent of countries have a relative price of services which is about 70 percent higher than the price in the poorest 10 percent of countries and the income elasticity of the relative price of services

Table 1: Relative Prices and Expenditure Shares

Deciles	RGDPpc	P_s/P	sQ_s	sE_s
1	0.02	0.54	0.48	0.30
2	0.03	0.60	0.52	0.37
3	0.05	0.55	0.44	0.28
4	0.09	0.59	0.49	0.32
5	0.13	0.60	0.49	0.34
6	0.19	0.66	0.50	0.40
7	0.27	0.68	0.50	0.39
8	0.41	0.74	0.47	0.40
9	0.67	0.90	0.47	0.50
10	0.89	0.94	0.43	0.48
Ratio D_{10}/D_1	49.2	1.75	0.91	1.60
Income elasticity	–	0.14	-0.01	0.14
		(0.02)	(0.02)	(0.02)

Notes: Countries are ranked according to real GDP per capita and divided among deciles. For each decile we report: (1) Real GDP per capita relative to that of the United States (RGDPpc), (2) the price of services relative to the price of GDP relative to that of the United States (P_s/P), (3) the real expenditure share of services to GDP (sQ_s), (4) the nominal expenditure share of services to GDP (sE_s). Income elasticity is the slope coefficient from an OLS regression of the log of each variable on log real GDP per capita across all countries in our sample (standard error in parenthesis).

is 0.14. This is a well-known fact that has been emphasized in the related literature (Kravis et al., 1983; Baumol et al., 1985; Summers and Heston, 1991; Heston and Summers, 1996).

We also note that the nominal expenditure share of services—the ratio of expenditures in services to total expenditures both in domestic prices—increases with income per capita. See Figure 1, bottom panel. While rich countries dedicate about 50 percent of their GDP in domestic prices to services, poor countries spend only 30 percent. This fact is also relatively well known (Duarte and Restuccia, 2010; Herrendorf et al., 2014). We also note that the real expenditure share of services—the ratio of expenditures in services to total expenditures both in common international prices—does not vary systematically with income per capita. That is, rich and poor countries spend about the same fraction of their real expenditures in services, at an average of around 50 percent for all countries.

Heterogeneity in services The set of categories that comprises services is very heterogeneous. For instance, it comprises categories such as hospital services, household services, insurance, among many others. The substantial heterogeneity within the services sector has long been recognized in the literature (Baumol et al., 1985; Eichengreen and Gupta, 2011; Jorgenson and Timmer, 2011). The detailed ICP price data also reflects this heterogeneity. The measure of heterogeneity that we focus on is the behavior of the price of individual categories (relative to that of GDP) against GDP per capita across countries. We focus on the income gradient of relative prices because we are interested in the productivity implications derived from them, following the emphasis in the seminal work of Baumol (1967).

We report the income elasticity of the relative price of individual categories—measured by the slope coefficient of an OLS regression of the relative price on real GDP per capita across countries—in Figure 2 and Tables 2 and 3 for all individual service categories as well as for the aggregates of manufacturing and services. As we discuss below, there is a simple mapping between the income elasticity of relative prices and the income elasticity of sectoral productivity and, as a result, the observations on relative prices directly pin down the productivity implications derived in the next section. We emphasize that the income elasticity of the relative price of individual categories in services lies in a wide range, from -0.59 to 0.40, as can be readily seen in Figure 2. That is, there are individual service categories for which its relative price rises systematically with income—such as domestic services, medical services, education, and housing—whereas others for which its relative price falls systematically with income such as transportation, communication, and financial services. The income elasticity of aggregate services is positive (0.14) because of the large share of housing, collective government, and health in total real expenditures in services. The wide range of elasticities in services—from very positive to very negative values—is an important component of the heterogeneity we highlight in services. For comparison, the elasticity coefficients for manufacturing categories lie in a much narrower and almost all negative range, between −0.37 and 0.05 and the income elasticity of the relative price of manufacturing is −0.07. We also find a larger dispersion of income elasticities of relative prices in services relative to manufacturing with a standard deviation of 0.2 across categories in services and 0.09 across manufacturing categories. The difference in standard deviations are quantitatively similar when we weight each sector category by either the U.S. expenditure shares or the world expenditure shares.

The striking fact that emerges from Figure 2 and Tables 2 and 3 is that many individual service categories in household consumption expenditures have a relative price that falls systematically with income, in sharp contrast to the income gradient of the relative price of aggregate services. The relative price behavior across countries for many individual categories in services in household consumption expenditures resembles more the relative price behavior of manufacturing goods than that of aggregate services.

Data from the 2011 ICP confirm these findings. The income elasticity of the relative price of services is positive (0.08) and the income elasticity of the relative price of manufacturing is negative (−0.05), whereas these elasticities are 0.14 and −0.07 in the ICP 2005. More importantly, as with the 2005 ICP data, we find substantial heterogeneity in the behavior of the relative price across individual service categories, with elasticities ranging between −0.36 and 0.40. In turn, elasticities for manufacturing categories in the 2011 ICP range between −0.31 and 0.15. The standard deviation of elasticities is 0.14 across manufacturing categories and 0.18 across categories in services.

Reallocation across services In order to provide a tractable characterization of the extent and implications of heterogeneity in the service sector, we divide services into two broad categories based on the income gradient of relative prices. The first broad category, which we refer to as traditional services, comprises the government and all service categories in

Table 2: Cross-Country Income Elasticity of Relative Prices

	Income Elasticity	Standard Error
Manufacturing	-0.07	0.02
Services	0.14	0.02
Disaggregated Services:		
Personal Consumption Expenditures		
Clothing and Footwear		
Cleaning and repair of clothing	-0.02	0.03
Repair and hire of footwear	0.08	0.03
Housing and Water		
Actual and imputed rentals for housing	0.21	0.05
Maintenance and repair of the dwelling	-0.16	0.04
Water supply	-0.21	0.06
Miscellaneous services relating to the dwelling	-0.18	0.04
Furnishings, Household Equipment, and Routine Maintenance of the House		
Repair of furniture, furnishings and floor coverings	-0.16	0.04
Repair of household appliances	-0.20	0.03
Domestic services	0.40	0.04
Household services	-0.14	0.02
Health		
Medical services	0.28	0.04
Dental services	0.24	0.04
Paramedical services	0.15	0.05
Hospital services	0.18	0.03
Transport		
Maintenance and repair of personal transport equipment	-0.12	0.03
Other services in respect of personal transport equipment	-0.17	0.03
Passenger transport by railway	-0.10	0.04
Passenger transport by road	-0.08	0.03
Passenger transport by air	-0.59	0.04
Passenger transport by sea and inland waterway	-0.28	0.02
Combined passenger transport	-0.20	0.03
Other purchased transport services	-0.15	0.03

Notes: The column Income Elasticity reports the slope coefficient of an OLS regression of the PPP price of each category relative to the PPP price of GDP on a constant and real GDP per capita. The column Standard Error reports the standard error of the slope coefficient.

Table 3: Cross-Country Income Elasticity of Relative Prices (Cont.)

	Income Elasticity	Standard Error
Communication		
Postal services	-0.15	0.04
Telephone and telefax services	-0.36	0.03
Recreation and Culture		
Repair of audio-visual and other equipment	-0.08	0.04
Veterinary and other services for pets	-0.14	0.02
Recreational and sporting services	0.07	0.04
Cultural services	-0.02	0.02
Games of chance	-0.13	0.02
Package holidays	-0.06	0.03
Education	0.22	0.04
Restaurants and Hotels		
Catering services	-0.10	0.02
Accommodation services	-0.24	0.03
Miscellaneous Goods and Services		
Hairdressing salons and personal grooming establishments	0.24	0.03
Prostitution	0.26	0.04
Social protection	-0.10	0.02
Insurance	-0.14	0.01
Financial intermediation services indirectly measured	-0.14	0.02
Other financial services n.e.c.	-0.14	0.03
Other services n.e.c.	-0.13	0.02
Government	0.21	0.03
Production of Health Services	0.21	0.04
Education	0.28	0.04
Collective Services	0.18	0.03

Notes: See notes in Table 2.

personal consumption expenditure for which its relative price increases with income across countries. Our nomenclature "traditional" follows a large literature in growth and development referring to sectors or activities featuring low growth or low productivity levels. The main components of traditional services are the government and, from personal consumption expenditures, actual and imputed rents for housing and health services. These three components represent at least 50 percent of real expenditures in traditional services in all countries. The cross-country average is 87 percent. The second broad category, which we call non-traditional services, comprises all other service categories, that is all service categories in personal consumption expenditures for which its relative price declines with income across countries. The main components of non-traditional services are transport services, communication services, and financial and related services. These three components represent, on average, 50 percent of real expenditures in non-traditional services. We emphasize that our classification of services into traditional and non-traditional is objective in that it is determined solely by whether their relative price rises or falls with income. Table 4 summarizes the price and expenditure facts for these two broad categories within services.

As per our construction of traditional and non-traditional service categories, the relative price of traditional services increases with income while the relative price of non-traditional services declines with income. The increase in the relative price of traditional services is 2.3-fold between the poorest decile to richest decile of countries, whereas the relative price of non-traditional services declines by more than 30 percent. The relative price of non-traditional to traditional services declines from 4.7 in the poorest decile of countries to 1.3 in the richest decile of countries. Note from Tables 2 and 3 that our non-traditional/traditional decomposition maps tightly to a decomposition of market/non-market services. Inklaar and Timmer (2014) decompose service industries into market and non-market and estimate that the relative output price of market services to non-market services declines with income across a relatively small set of countries.

Table 4: Relative Prices and Expenditure Shares within Services

Deciles	RGDPpc	P_{s_T}/P	P_{s_N}/P	sQ_{S_T}	sE_{S_T}	sQ_{S_N}	sE_{S_N}
1	0.02	0.38	1.82	0.42	0.21	0.05	0.09
2	0.03	0.44	1.64	0.45	0.27	0.07	0.09
3	0.05	0.39	1.56	0.38	0.19	0.07	0.09
4	0.09	0.43	1.21	0.38	0.22	0.11	0.11
5	0.13	0.49	1.08	0.38	0.24	0.11	0.10
6	0.19	0.51	1.14	0.37	0.26	0.13	0.14
7	0.27	0.55	1.12	0.35	0.25	0.15	0.14
8	0.41	0.62	1.13	0.32	0.26	0.14	0.14
9	0.67	0.81	1.08	0.29	0.32	0.18	0.18
10	0.89	0.86	1.12	0.25	0.29	0.18	0.19
Ratio D_{10}/D_1	49.2	2.25	0.61	0.59	1.35	3.49	2.22
Income elasticity	–	0.21	-0.13	-0.12	0.09	0.38	0.25
		(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)

Notes: Countries are ranked according to GDP per capita and divided among deciles. For each decile, we report: (1) GDP per capita relative to that of the United States (RGDPpc), (2) the price of traditional services relative to the price of GDP (P_{s_T}/P), (3) the price of non-traditional services relative to the price of GDP (P_{s_N}/P), (4) the real expenditure share of traditional services to GDP (sQ_{s_T}), (5) the nominal expenditure share of traditional services to GDP (sE_{s_T}), (6) the real expenditure share of non-traditional services to GDP (sQ_{s_N}), and (7) the nominal expenditure share of non-traditional services to GDP (sE_{s_N}). Income elasticity is the slope coefficient from an OLS regression of the log of each variable on log real GDP per capita across all countries in our sample.

There is substantial variation in the shares of expenditures within services across countries. The nominal share of traditional services (in total services) declines with income while the nominal share of non-traditional services increases with income. This reallocation between the two broad service categories is substantial and even stronger in real terms, with poor countries allocating most of the real expenditure in services to traditional services whereas rich countries allocate around 45 percent of the real service expenditure to non-traditional services, as documented in Figure 3. We note that not all individual expenditure categories conform with the reallocation pattern of the aggregated categories. For instance, recreational services, rents, and some medical services that are traditional services according to the income gradient of their relative prices, have a positive (albeit small) income elasticity of real expenditure shares.

In sections 3 and 4, we assess the productivity implications of heterogeneity in the service sector and its aggregate implications across countries.

2.2 U.S. Data

Our characterization of relative prices and sectoral structure has so far relied on a cross-section of countries that differ in their level of development. We now provide evidence on the evolution of the sectoral structure and relative prices for an individual country as it develops. We document the time-series behavior of the nominal and real shares of non-traditional services and its relative price using detailed expenditure data for the United States from 1950 to 2015.[4] We allocate the available expenditure categories for the United States to match the traditional and non-traditional service categories defined for the ICP data.

The top panel in Figure 4 shows the nominal and real shares of total services in GDP in the United States between 1950 and 2016. The nominal share increased substantially in this time period, from 41 to 63 percent, while the real share is roughly constant. These shares reflect, as in the cross-country data, a rising price of services relative to that of GDP over this period (from about 0.63 in 1950 to 1.04 in 2016). When we decompose services, we find that there has been a reallocation of expenditures from traditional to non-traditional services in the United States between 1950 and 2015, documented in the bottom panel of Figure 4. Over this time period, the real share of non-traditional services (in total services) rose by about 10 percentage points, from about 26 to 37 percent, while the nominal share rose by less. The income elasticities of the nominal and real shares of non-traditional services in total services are 0.1 and 0.3, respectively. The corresponding income elasticities in the cross-country data

[4] See appendix A.2 for details.

are 0.12 and 0.39. Figure 5 plots the relative price deflator of non-traditional to traditional services. This relative price fell in this time period from about 1.5 in 1950 to 0.95 in 2015 and its income elasticity is -0.31. The income elasticity of this relative price in the cross-country data is -0.34.

Overall, these facts for the sectoral structure and relative prices of traditional and non-traditional services in the United States over time are consistent with our findings for the cross-section of countries and reinforce our interpretation in their connection with the process of development. As emphasized earlier for the cross-country evidence, we note that our evidence for the United States does not imply that all individual service categories match the behavior in the aggregated sector or that of the cross-country data. For example, the real share of expenditures in education and health—two categories in traditional services—rises in the United States over some periods, whereas in the cross-country data, the real share in education and some health categories fall with the level of development. A more disaggregated analysis of the behavior of real expenditure shares in the time series of the United States and in the cross-country data may be useful in identifying relevant channels and potential sources of variation.

2.3 Discussion

We have documented substantial heterogeneity in the income elasticity of the relative price of individual service categories across countries. We now discuss the forces that may be behind this differential relative price behavior of individual service expenditure categories as well as measurement issues related to the role of government and cross-country price differences, specially for non-market services.

Drivers of relative price differences The main empirical finding we have emphasized is the heterogeneity among individual expenditure categories in services on the income elasticity of relative prices which contrasts with non-service categories. In particular, we have found that for many individual service categories, the income elasticity of the relative price is negative and for some categories even smaller than that of manufacturing. What drives this heterogeneity? Our starting point is that, as we develop in the next section, these relative price differences reflect differences in productivity, as emphasized by Baumol (1967). But this theory encompasses many complementary explanations for the behavior of productivity, which may be intrinsic to the industry/product, such as whether the good/service is tradable or not, whether the good/service is provided by the government and hence not marketed, or whether there are market imperfections or policy-induced distortions (such as restrictions to international trade) that affect the level of competition and hence affect productivity growth of the industry.

The facts we have documented are based on relative prices and it would be comforting to have at least some direct evidence on productivity growth. This evidence is of course not available across countries and hence the value of documenting the behavior of relative prices. However, time series data for the United States suggest a tight association between our characterization of services between traditional and non-traditional and productivity growth. Duernecker et al. (2016) document average annual growth rates of labor productivity between 1947 and 2010 for 13 (private) service industries in the United States. They find a large range of growth rates and aggregate service industries into two broad sub-sectors: services with fast and slow productivity growth. Their assignment of industries is nearly identical to ours. That is, all service industries that they identify as "fast growth" are in non-traditional services and all service industries but one that they identify as "slow growth" are in traditional services.

Similarly, inspecting the individual categories that feature a positive or negative income elasticity of relative price, we confirm that they roughly correspond to more subjective characterizations of non-market and market services or non-tradable and tradable services.

But again, in our view this connection occurs because of the effect that marketability and tradability of services imply for competition and productivity growth.

The importance of government As is standard in the literature, services include the government and, given the behaviour of its relative price, it was assigned to traditional services in our analysis. We recognize the issues of measurement associated with government services, but despite these limitations we include government in our analysis because the scope of the government in services varies greatly across countries. However, we note that our findings are robust to excluding government from the analysis. We observe a relative price of services, excluding government, that rises systematically with income, in line with the behavior of the relative price of aggregate services in Figure 1, top panel. The income elasticity of the relative price of services excluding government is 0.09 (compared to 0.14 when including government). The income elasticity of traditional services excluding government is 0.21, the same as including government. In addition, we also observe a strong reallocation from traditional services, excluding government, to non-traditional services along the development path: in the bottom decile of the income income distribution, the real share of non-traditional services in total services excluding government is 0.24 and in the top decile this share is 0.58.

Other measurement issues It is not the intention of our analysis to provide an improved measurement of services, instead, we are interested in the patterns of relative prices underlying the actual data for GDP across countries. In this context, an important question related to our analysis is: how reliable are the price observations across countries from the ICP? We emphasize that the ICP is an enormous and ambitious statistical undertaking. It is clear from the methodological underpinnings that the best statistical methods are used as well as substantial data-collection efforts and consistency/accuracy checks are followed to provide the most accurate picture of price comparisons across countries. Importantly for our purposes is that the ICP follows a basic principle guiding the price collection which is that prices should be consistent with those underlying national accounts expenditure data in each country. This does not mean that ICP is absent of errors, measurement, and methodological issues and, in fact, ICP adjusts methods in each round based on experience, improved availability of data, and new techniques and, as a result, the magnitude of differences in GDP and price levels invariably vary. But we argue that the methods followed and data efforts provide the best picture available for price comparisons across countries and that the findings cannot be simply dismissed on measurement grounds.

The basic data requirements for ICP in each country are: (a) estimates of GDP and its expenditure disaggregates (129 basic headings) in national currency using the System of National Accounts 1993 and (b) national annual average prices for a set of well-defined goods and services for each basic heading. We focus on describing the price collection efforts and the specifics of more difficult items such as government and non-market services, as well as housing and health. Price comparisons follow the principle of matching "like with like" to maximize comparability. For this reason, price-determining characteristics are specified for each product. The number of products specified varies across headings. For example, "Postal Services" is covered with a small number of products whereas "Bread" needs a large number of products to be specified in order for its price to be representative within and across countries. Product coverage is determined in order to strike the most reasonable balance between representativeness of prices in the basic heading in a country with comparability of each category across countries.

There are a number of service expenditure components of GDP that are intrinsically more difficult to estimate (such as housing, collective government consumption, health, and education). We describe the details followed on these categories to illustrate the efforts made. For Housing, the national accounts measure actual rents and inputed rents for owner-occupied housing. But calculating PPPs for rents is challenging because in some countries the rental market is small, rendering noisy average prices. The ICP has developed a specific questionnaire to obtain detailed data underlying the estimates of dwelling stocks used in national accounts for rented and owner-occupied housing (details such as number of dwellings, number of rooms, square footage by type of dwelling, by region, locality, facilities available such as utilities, private toilet, etc.). Starting in 2005, the ICP has mainly used one or a combination of approaches to compute PPPs for housing rent: the quantity method based on the questionnaire above and the direct rent approach when rental data is representative.

For government, the ICP follows the national accounting convention of measuring non-market output by the input-cost approach. The key component of government expenditures is compensation for employees. The ICP computes PPPs for compensation of employees by comparing salaries across countries for several detailed and well-defined jobs that are representative of government expenditures around the world. For health, the ICP includes basic heading for medical products and health services under both household consumption and individual consumption by government, in addition to other government categories for the production of health services. The ICP prices for health reflect the total price regardless of who pays for the service. Prices of products are collected (either paid in full by the consumer, partially paid by private insurance, or fully paid by the government). For products partially paid by consumers and government, the total amount is recorded. Hence, the PPP for consumption expenditure on health services includes a combination of prices paid by consumers as well as government contributions which includes input costs such as compensation of employees. Overall, there is an extensive effort in PPP prices to address consistency with GDP measurement, representativeness of basic headings across the world, and comparability across countries.

We conclude from this brief description of the ICP data that mis measurement of non-market prices is not the most likely explanation for the rising relative price of traditional services with development. We also emphasize that by inspecting the basic heading categories, products within those categories can differ in the extent to which the product is traded internationally or whether it reflects non-market services, but the pricing approach of the ICP attempts to deal with these issues. Finally, we highlight that our documentation of relative prices for disaggregate services challenges the consensus view of aggregate services precisely for the service categories that we can more reliably measure their price. For the service categories that we can better measure their price, and in sharp contrast to the behaviour of aggregate services, we find that their relative price falls systematically with income. As a result, we believe that the relative price implications of the ICP data are important in providing guidance as to productivity implications for services.

3 Productivity Implications

We ask the following question: What are the productivity implications of disaggregating the service sector? We assess the importance of heterogeneity within services for sectoral productivity across countries by following a large literature in conducting a development accounting exercise. Although using expenditure data is not our preferred approach for the same reasons emphasized in Heston and Summers (1996), we highlight the importance of heterogeneity in services by staying close to the existing literature and using the same methodology and data. We then extend our accounting framework to consider the role of input-output linkages across sectors.

3.1 Basic Framework

We follow Herrendorf and Valentinyi (2012) in considering a development accounting framework that imposes minimal structure. There are N sectors indexed by i in the economy which we map to the level of basic-heading data from the ICP or any aggregate from those categories. Production in each sector is governed by linear technologies requiring labor input:

$$Y_i = A_i L_i, \qquad \forall i,$$

where Y_i and L_i are output and labor in sector i and A_i is labor productivity in sector i. Notice that, given the functional form for production in each sector, data on output and labor across sectors and countries can directly pin down the variables of interest, i.e., A_i for all countries and sectors. However, such data does not exist, at least for a comprehensive set of sectors and for a large number of countries. The main difficulty is that what is available is the value of output across sectors and countries and these values can reflect differences in relative prices across sectors within a country as well as differences in relative prices across countries, potentially confounding true differences in real productivity. In addition, even if we could make a mapping from the real expenditure data to output in a sector, generally we do not have the corresponding labor input associated with that sector specification. Hence, more structure is needed before we can identify A_i across sectors and countries using data. We note that labor productivity in each sector is summarized in the model by the productivity parameter A_i. There are many features that can explain differences across countries in labor productivity, such as capital intensity and factor endowments, and accounting for these sources can provide a better understanding of labor productivity facts. Our analysis abstracts from the sources driving labor productivity observations.

We proceed by assuming, in addition to linear technologies in labor, competitive markets for goods and labor, and perfect factor mobility across sectors. With these assumptions, the value of labor productivity (the marginal product of labor in this case) is equalized across sectors. The stand-in firm in each sector maximizes profits by choosing an appropriate amount of labor, which requires,

$$p_i A_i = w \qquad \forall i, \tag{1}$$

where w is the common wage rate and p_i is the price of output in sector i. Then, it follows that the (domestic price) value of aggregate output is $\sum_i p_i Y_i = wL$, where $L = \sum_i L_i$ is the total amount of labor in the country. Hence, the wage rate is the nominal value of output per capita. We also note that the share of labor allocated to each sector is given by the value of output in the sector relative to the total, $L_i/L = p_i Y_i / \sum_i p_i Y_i$. More directly, we can use equation (1) to solve for sectoral labor productivity A_i. Dividing the numerator and denominator by the price of GDP, p, we obtain

$$A_i = \frac{w/p}{p_i/p}, \qquad \forall i. \tag{2}$$

To implement this development accounting empirically, we note that w/p is real GDP per capita in each country and p_i/p is the price of output of sector i relative to the price of GDP, both of which are readily available in the cross-country data documented earlier.[5] For each sector and country, we calculate labor productivity (A_i) and compute statistics from them to illustrate how sectoral productivity varies with GDP per capita in the cross-country data. Moreover, taking the log of equation (2) results in,

$$\log(A_i) = \log(w/p) - \log(p_i/p).$$

It is straightforward to note that the income elasticity of sectoral productivity A_i—the derivative of $\log A_i$ with respect to log real GDP per capita—is one minus the income elasticity of the sectoral relative price, providing a simple mapping between the relative price facts documented earlier and the income elasticity of sectoral productivity from which we can derive productivity implications. We compute the income elasticity of sectoral productivity by using the income elasticities of relative prices reported in Tables 2 and 3.

To illustrate the productivity implications of relative prices, consider income elasticities of relative prices of -0.20 and 0.20, as is the case for many categories in Tables 2 and 3. The

[5] We note that our analysis would be similar using GDP per worker instead of GDP per capita since the employment to population ratio does not vary systematically with development.

implied income elasticities of sectoral productivity would be 1.2 and 0.80. We can then use these elasticities to assess the sectoral productivity implications between the richest and poorest 10% of countries whose real GDP per capita ratio is a factor of 49.2-fold. The implied sectoral productivity ratios (the ratio of sectoral productivity between rich and poor countries) would be a factor of 107.2-fold ($\exp(1.2 \times \log(49.2))$) and 22.6-fold ($\exp(0.8 \times \log(49.2))$) respectively. For the manufacturing sector, whose income elasticity of relative price is -0.07, the income elasticity of manufacturing productivity is 1.07, and hence the ratio of manufacturing productivity between the richest and poorest 10% of countries would be a factor of 64.6-fold ($\exp(1.07\times\log(49.2))$). These are stark differences in relative productivities derived from relative price behavior within service categories and even compared to the manufacturing sector.

The cross-country income elasticities of relative prices provide a convenient summary statistic for the productivity implications. Table 5 also reports the accounting for each individual country grouped by deciles of the income distribution and for the aggregate of manufacturing and services and the sub aggregates of traditional and non-traditional services.

The cross-country variation in manufacturing productivity is larger than that in aggregate services since the income elasticity in manufacturing is larger than aggregate services. A one percent higher income per capita translates into about a 1.07 percent higher productivity in manufacturing productivity whereas only a 0.86 percent higher productivity in aggregate services. For the ratio of the 10 percent richest and poorest countries, differences in manufacturing productivity are close to 70-fold while for services only 27-fold. These results are consistent with the findings in the related literature such as Baumol (1967), Hsieh and Klenow (2007), Herrendorf and Valentinyi (2012), and the literature emphasizing productivity differences between the tradable and non-tradable sectors (Kravis et al., 1983).

For disaggregated services, the accounting results are markedly different in that traditional services feature lower differences in productivity than manufacturing, which are critical in

Table 5: Development Accounting Results

	Relative GDPpc	A_i			
		m	s	s_T	s_N
D_1	0.02	0.01	0.04	0.05	0.01
D_2	0.03	0.02	0.06	0.08	0.02
D_5	0.13	0.07	0.24	0.31	0.14
D_9	0.67	0.53	0.74	0.83	0.62
D_{10}	0.89	0.75	0.95	1.05	0.80
Ratio D_{10}/D_1	49.2	68.8	27.2	21.1	75.5
Income elasticity	–	1.07	0.86	0.79	1.13
		(0.02)	(0.02)	(0.02)	(0.02)

Notes: A_i refers to labor productivity in each sector. The income elasticity is the slope coefficient from an OLS regression of log productivity on log GDP per capita across all countries in our sample. Standard errors are in parenthesis. D_{10}/D_1 is the ratio of average labor productivity in each sector in the richest and poorest 10% of countries.

determining the implications for aggregate services since traditional services are almost all the services in poor countries and around 55 percent in rich countries. The cross-country differences in productivity in non-traditional services resemble more those of manufacturing. Using the income elasticity as a summary indicator of differences in productivity across countries, non-traditional services feature a larger elasticity than manufacturing and much larger than traditional services. These results are broadly in line with productivity measurement for specific industries within services and manufacturing (Baily and Solow, 2001).

3.2 Input-Output Structure

We extend the basic framework, following Ngai and Samaniego (2009), to incorporate the input-output structure of the economy. We use this extended framework to assess the quantitative relevance of sectoral linkages for productivity implications.

There are many production sectors in the economy indexed by i. The technology to produce output in each sector is given by the the gross-output production function,

$$q_i = B_i l_i^{1-\alpha_i} h_i^{\alpha_i}, \qquad \forall i, \tag{3}$$

where B_i is the productivity level of gross output, l_i is the labor input, and h_i is the composite of intermediate inputs used in sector i. The share of produced inputs in each sector is α_i and the intermediate input composite h_i is given by

$$h_i = \prod_j \left(\frac{g_{ji}}{\varphi_{ji}}\right)^{\varphi_{ji}}, \quad \sum_j \varphi_{ji} = 1, \quad \varphi_{ji} > 0, \tag{4}$$

where g_{ji} is the quantity of intermediate input j used in sector i.

The representative firm in sector i solves the problem

$$\max_{l_i, \{g_{ji}\}_j} \left\{ p_i q_i - \sum_j p_j g_{ji} - w l_i \right\} \tag{5}$$

subject to (3) and (4). Note that the first two terms in the profit function of problem (5), the value of gross output minus the cost of intermediate inputs, is value added which we denote as $p_i^y y_i$,

$$p_i^y y_i \equiv p_i q_i - \sum_j p_j g_{ji}. \tag{6}$$

The first order condition of profit maximization in problem (5) with respect to intermediate input use g_{ji} implies,

$$\alpha_i \varphi_{ji} p_i q_i = p_j g_{ji}, \qquad \forall j, \tag{7}$$

from which we can derive the optimal demand for intermediate inputs. Using these optimal demands in equations (3) and (4), we obtain gross output as a function of only labor and prices,

$$q_i = B_i^{\frac{1}{1-\alpha_i}} l_i \left(\frac{\alpha_i p_i}{p_{h_i}}\right)^{\frac{\alpha_i}{1-\alpha_i}}, \tag{8}$$

where p_{h_i} is the price index of intermediate composite h_i given by $p_{h_i} = \prod_j p_j^{\varphi_{ji}}$. Using the definition of value added in equation (6) and substituting for output and intermediate inputs from equations (8) and (7), we obtain

$$p_i^y y_i = p_i \left(\frac{p_i}{p_{h_i}}\right)^{\frac{\alpha_i}{1-\alpha_i}} (1-\alpha_i)\alpha_i^{\frac{\alpha_i}{1-\alpha_i}} B_i^{\frac{1}{1-\alpha_i}} l_i,$$

where the price of value added is given by

$$p_i^y = p_i \left(\frac{p_i}{p_{h_i}}\right)^{\frac{\alpha_i}{1-\alpha_i}},$$

and real value added is given by

$$y_i = A_i l_i,$$

where $A_i = (1-\alpha_i)\alpha_i^{\frac{\alpha_i}{1-\alpha_i}} B_i^{\frac{1}{1-\alpha_i}}$ is value added productivity.

The first order condition of profit maximization in problem (5) with respect to the labor allocation across sectors is given by $p_i^y A_i = w$. Hence, as in the basic framework, sector productivity is the ratio of wage to sector price, where now the sector price is the price of value added which depends on the prices of all other sectors through intermediate input linkages. That is,

$$A_i = \frac{w}{p_i^y}, \qquad \text{where} \quad p_i^y = p_i \left[\prod_j \left(\frac{p_i}{p_j}\right)^{\varphi_{ji}}\right]^{\frac{\alpha_i}{1-\alpha_i}}.$$

Hence, sector productivities can be expressed as a simple function of relative income per capita and relative sector gross-output prices, and a term reflecting the input-output structure as follows,

$$A_i = \frac{w/p}{p_i/p} \cdot \frac{1}{\left(\frac{p_i}{p}\right)^{\frac{\alpha_i}{1-\alpha_i}} \left[\prod_j \left(\frac{p_j}{p}\right)^{-\varphi_{ji}}\right]^{\frac{\alpha_i}{1-\alpha_i}}}. \tag{9}$$

As a result, sector productivities are identical to the framework without intermediate inputs when $\alpha_i = 0$ for all i. Also, the difference between sector productivities with and without the input-output structure depends on the magnitude of the second term on the right-hand side of equation (9). Taking logs and rearranging we obtain,

$$\log(A_i) = \log(w/p) - \log(p_i/p) - \frac{\alpha_i}{1-\alpha_i} \sum_j \varphi_{ji} [\log(p_j/p) - \log(p_i/p)]. \tag{10}$$

Assuming for now that α_i's are constant across countries, the deviation of sector productivities with respect to the basic framework depends on the third term of the above expression which in turn depends on the income elasticity of relative prices (between the price of input j and sector price i) and the corresponding shares α_i and φ_{ji}. Note that when φ_{ii} is high (which occurs when the sector uses it own output as main input), this term is close to zero as the $j = i$ term in square brackets is zero. Hence, we expect that input-output linkages have smaller productivity implications when the share of intermediate inputs in gross output is smaller, when the share of intermediate inputs sourced from other sectors is smaller, and when the share of intermediate inputs with different relative price is smaller, all else equal.

To derive quantitative implications, we need to characterize the values for α_i and φ_{ji} for all i and j and across countries. We use data from WIOD. This database includes national input-output tables for 40 countries from 1995 to 2011, in a 35 by 35 industry classification. As a result, we are unable to quantify the input-output implications at the same level of disaggregation as in the ICP data where we derived the relative price facts. Following our previous analysis, we aggregate the input-output tables into 4 sectors: manufacturing, traditional services, non-traditional services, and other. We then consistently compute input-output parameters for 3 sectors: manufacturing, traditional services, and non-traditional services. See Appendix A.3 for further details.

For each sector, we compute the share of intermediate inputs in gross output and we find that these shares are fairly stable over time and across countries. The first panel in Figure 6 plots the 3 sectoral shares in the United States between 1995 and 2011. For the United States, the average share of intermediate inputs in this period is 0.61 in the manufacturing sector, 0.32 in the non-traditional services sector, and 0.37 in the traditional services sector. The remaining three panels in Figure 6 plot, for each sector, the average share of intermediate inputs for each country in the WIOD database. In these panels, the red-dotted line marks the time series average for the United States. We find that these average shares do not vary systematically with income. For each sector, we also compute the share of each good in the intermediate input composite. The first panel in Figures 7, 8, and 9 plots the time-series for each of these shares in the United States. We find that these shares are also fairly stable over time in the United States. The remaining panels in Figures 7, 8, and 9 plot the time-series average for all the countries in the dataset. We also find that these shares tend to not vary systematically with income across countries, with the exception of the share of manufacturing and non-traditional services used in the production of traditional and non-traditional services. It is worth noting that traditional and non-traditional services differ in a systematic way with respect to their use as intermediate inputs, with a higher share of non-traditional services output being used as intermediate inputs than the share of traditional services output. These difference occurs even though the characterization of services (as traditional or non-traditional) is independent of their use as intermediate inputs.

We report the cross-country productivity implications in Table 6. For the results in this table we set the input-output parameters for all countries equal to their average values from the time series for the United States. We report results with input-output linkages, as well as statistics for the case without intermediate inputs (i.e., when $\alpha_i = 0$ for all i's). We find that taking the input-output structure into account makes the gap in productivity between non-traditional and traditional services even larger, and the productivity dispersion in manufacturing somewhat smaller compared to the setting without intermediate inputs. Consistent with the intuition associated with equation (10), the main impact of the input-output structure is on the dispersion of productivity in traditional services, because this is the sector that uses very little of its own output as an intermediate input.

Table 6: Development Accounting with Input-Output Linkages

	A_m	A_{s_T}	A_{s_N}
With intermediate inputs:			
D_1	0.01	0.09	0.01
D_2	0.02	0.13	0.02
D_5	0.05	0.48	0.15
D_9	0.49	0.94	0.61
D_{10}	0.71	1.17	0.80
Ratio D_{10}/D_1	66.0	12.5	81.2
Income elasticity	1.05	0.67	1.15
	(0.04)	(0.03)	(0.02)
Without intermediate inputs:			
Ratio D_{10}/D_1	68.8	21.1	75.5
Income elasticity	1.07	0.79	1.13
	(0.02)	(0.02)	(0.02)

Notes: A_i refers to labor productivity in each sector. The income elasticity is the slope coefficient from an OLS regression of log productivity on log GDP per capita across all countries in our sample. Standard errors are in parenthesis. D_{10}/D_1 is the ratio of average labor productivity in each sector in the richest and poorest 10% of countries.

3.3 Robustness

We assess the robustness of the role of input-output linkages for productivity implications in two ways. First, we assess the role of differences in the input-output structure across countries. To this end, we restrict analysis to the 37 countries for which we have both ICP and WIOD data. We derive productivity implications for these 37 countries using country-specific input-output parameters and we compare these results to those obtained when using the US averages (as in Table 6). The results are reported in Table 7.

Table 7: Development Accounting Robustness - Restricted Sample

	A_m	A_{s_T}	A_{s_N}
Country-specific IO parameters:			
D_1	0.05	0.27	0.09
D_2	0.09	0.59	0.28
D_5	0.25	0.85	0.53
D_9	0.64	1.09	0.71
D_{10}	0.77	1.08	0.85
Ratio D_{10}/D_1	14.7	4.0	9.1
Income elasticity	1.35	0.63	0.99
	(0.08)	(0.06)	(0.03)
US IO parameters:			
D_1	0.05	0.27	0.09
D_2	0.09	0.59	0.26
D_5	0.25	0.82	0.51
D_9	0.63	1.08	0.71
D_{10}	0.76	1.07	0.85
Ratio D_{10}/D_1	14.8	4.0	9.3
Income elasticity	1.35	0.61	1.01
	(0.08)	(0.06)	(0.02)

Notes: See notes for Table 6. Sample is restricted to 37 countries.

We find that results are not affected by using country-specific input-output parameters instead of U.S. values. Earlier we documented that the input-output structure is fairly stable across the countries covered in the WIOD database, except for the composition of the intermediate composite used in the production of traditional and non-traditional services. The results in Table 7 suggest that these trends have a minor impact on the role of input-output linkages for productivity implications. Note that the set of countries for which we have both ICP and WIOD data is not representative of the entire set of countries in the ICP data. In particular, this restricted set does not include the poorest countries in the world (for instance, the ratio of GDP per capita between the 10% richest to the 10% poorest is 7.9 in this restricted dataset while this ratio is 49.2 in the ICP dataset).

Table 8: Development Accounting Robustness - Full Economy

	A_m	A_{s_T}	A_{s_N}	A_o
With intermediate inputs:				
D_1	0.01	0.10	0.01	0.01
D_2	0.02	0.14	0.02	0.02
D_5	0.04	0.52	0.15	0.09
D_9	0.47	0.96	0.61	0.66
D_{10}	0.69	1.19	0.80	0.93
Ratio D_{10}/D_1	64.0	11.5	81.2	73.1
Income elasticity	1.04	0.65	1.15	1.13
	(0.04)	(0.03)	(0.02)	(0.03)
Without intermediate inputs:				
D_1	0.01	0.05	0.01	0.01
D_2	0.02	0.08	0.02	0.02
D_5	0.07	0.31	0.14	0.09
D_9	0.53	0.83	0.62	0.62
D_{10}	0.75	1.05	0.80	0.86
Ratio D_{10}/D_1	68.8	21.1	75.5	72.6
Income elasticity	1.07	0.79	1.13	1.11
	(0.02)	(0.02)	(0.02)	(0.01)

Notes: See notes for Table 6. Economy is not restricted to three sectors. A_o refers to labor productivity in sector "Other."

Second, we assess the impact for our results of restricting the economy to three sectors. In Table 8 we report results for the full economy, comprised of four sectors: manufacturing, traditional services, non-traditional services, and other (mostly agriculture), using the input-output parameters estimated for the 4-sector economy. The results indicate that the productivity implications from developing accounting for manufacturing and both types of services are well captured in the economy restricted to these three sectors. For instance, the income elasticities of sectoral productivity are 1.04 in manufacturing, 0.65 in traditional services, and 1.15 in non-traditional services when the accounting consists of the entire economy, whereas these elasticities are nearly identical, 1.05, 0.67, and 1.15 respectively when the accounting includes only three sectors.

4 Quantitative Analysis

Our previous analysis on the implications of relative prices for sectoral productivity is silent about aggregate outcomes such as aggregate productivity as well as the forces that drive reallocation across sectors. To address these issues and to perform counterfactual experiments, we develop a sectoral model that features an input-output structure along the lines of the development accounting in Section 3.

4.1 Description

We develop a general equilibrium multi-sector model that builds on Duarte and Restuccia (2010) and Ngai and Samaniego (2009).[6] There are three sectors: manufacturing, traditional services, and non-traditional services. Production requires the use of labor and intermediate inputs and we model the use of intermediate inputs in an input-output structure. We consider preferences that allow for substitution between traditional and non-traditional services as a result of changes in relative prices, in line with data as discussed below.

Households There is a stand-in representative household with preferences over consumption of manufactured goods (m) and two types of services, traditional services (s_T) and

[6] We build from a large quantitative literature emphasizing structural change such as Echevarria (1997), Kongsamut et al. (2001), Gollin et al. (2002), and Ngai and Pissarides (2007). See also the related work in the development literature emphasizing the importance of the input-output structure such as Jones (2011), Moro (2012), and Grobovsek (2013).

non-traditional services (s_N):

$$u(c_m, c_{s_T}, c_{s_N}) = b\log(c_m) + \frac{(1-b)}{\rho}\log\left[\phi(c_{s_T})^\rho + (1-\phi)(c_{s_N})^\rho\right], \tag{11}$$

with b and ϕ between 0 and 1, and $\rho \in (-\infty, 1]$. Households are endowed with l units of productive time each period which can be allocated to work in any sector. There are no frictions to labor allocation across sectors; for the household to allocate hours in all sectors, the wage in each sector must be equal and we denote it by w.

Production There are three production sectors in the economy: manufacturing, traditional services, and non-traditional services. The representative firm in each sector has access to the gross-output production function given by equation (3) for $i \in \{m, s_T, s_N\}$. The share of produced inputs in each sector is α_i and the intermediate input composite h_i is given by equation (4). We denote by g_i the total amount of good i used as an input to production and p_i the price of good i, $i \in \{m, s_T, s_N\}$.

Equilibrium A *competitive equilibrium* is a set of prices $\{p_m, p_{s_T}, p_{s_N}, w\}$ and allocations $\{c_m, c_{s_T}, c_{s_N}, l_m, l_{s_T}, l_{s_N}, g_{jm}, g_{js_T}, g_{js_N}\}_{j=m,s_T,s_N}$ such that:

(*i*) Given prices, $\{l_i, g_{mi}, g_{s_T i}, g_{s_N i}\}$ solve the sector i representative firm problem:

$$\max_{l_i, g_{mi}, g_{s_T i}, g_{s_N i}} \left\{ p_i q_i - w l_i - \sum_{j=m,s_T,s_N} p_j g_{ji} \right\} \tag{12}$$

subject to (3) and (4).

(*ii*) Given prices, $\{c_m, c_{s_T}, c_{s_N}\}$ solve the household's problem:

$$\max_{c_m, c_{s_T}, c_{s_N}} u(c_m, c_{s_T}, c_{s_N}) \tag{13}$$

subject to

$$p_m c_m + p_{s_T} c_{s_T} + p_{s_N} c_{s_N} = wl.$$

(iii) Any good or service produced in the current period can be consumed or used as input to production. All firms produce for the final goods market and the intermediate input market. There is no distinction between firms producing final goods and firms producing intermediate inputs. The market clearing conditions for each sector are

$$c_i + g_i = q_i, \quad i \in \{m, s_T, s_N\}, \quad \text{where} \quad g_i = \sum_{j=m,s_T,s_N} g_{ij}.$$

Market clearing in the labor market requires,

$$\sum_{i=m,s_T,s_N} l_i = l.$$

4.2 Calibration

We calibrate the benchmark economy to data for the United States. As discussed earlier, for the parameters governing the input-output structure, we use data from the World Input-Output Database (WIOD) and set these parameters equal to the time-series average for the United States. We normalize the productivity level in traditional services ($B_{s_T}^{US}$) to one. We set $\rho = 0.25$ to allow for reallocation of expenditures between traditional and non-traditional services as a result of relative price changes and we discuss the sensitivity of the results to changes in this parameter. The productivity levels in manufacturing (B_m^{US}) and non-traditional services ($B_{s_N}^{US}$) and the preference parameters b and ϕ are pinned down jointly to match four targets from the ICP dataset: the price of traditional and non-traditional services relative to manufacturing, the ratio of real consumption expenditures in manufacturing to traditional services and the ratio of real consumption expenditures in traditional services to non-traditional services in the United States. The parameter values are reported in Table 9.

Table 9: Calibration

Parameter	Value	Target U.S. Data
$\alpha_m, \alpha_{s_T}, \alpha_{s_N},$	0.61,0.32,0.37	Share of interm. inputs in sectoral gross output
$\varphi_{mm}, \varphi_{s_N m}$	0.64, 0.34	Share of m and s_N in h_m
$\varphi_{s_T s_T}, \varphi_{s_N s_T}$	0.18, 0.61	Share of s_T and s_N in h_{s_T}
$\varphi_{s_N s_N}, \varphi_{m s_N}$	0.77, 0.14	Share of s_N and m in h_{s_N}
ρ	0.25	Baseline
B_{s_T}	1.0	Normalization
B_m, B_{s_N}	1.9, 1.5	Relative prices p_{s_T}/p_m and p_{s_N}/p_m
b	0.33	Ratio of real expenditures c_m/c_{s_T}
ϕ	0.59	Ratio of real expenditures c_{s_T}/c_{s_N}

4.3 Cross-Country Sectoral Productivity

We measure sectoral relative labor productivity (A_m, A_{s_T}, A_{s_N}) for each country in the ICP dataset using the model. Following the approach in Duarte and Restuccia (2010), we impose three targets and solve for the three gross output productivity levels B_i. We then obtain sectoral labor productivity as $A_i = (1-\alpha_i)\alpha_i^{\frac{\alpha_i}{1-\alpha_i}} B_i^{\frac{1}{1-\alpha_i}}$. The three targets are: (1) the price of traditional services relative to that of manufacturing; (2) the price of non-traditional services relative to that of manufacturing; and (3) aggregate labor productivity relative to that of the United States.

To implement this exercise, we need to map model variables to data in order to match these three targets. For the first two targets, relative prices p_{s_T}/p_m and p_{s_N}/p_m in the model map directly to the corresponding relative prices from the ICP dataset. Our third target imposes that, for each country, the model matches data on aggregate labor productivity in the manufacturing and service sectors relative to that of the United States. For this target, we need to compute aggregate labor productivity in the model, which maps to real output per worker in manufacturing and services in the data. In the model, aggregate GDP in domestic prices can be calculated for each country from the production side as $Y = \sum_i p_i^y y_i$ or from the expenditure side as $Y = \sum_i p_i c_i$. To compare quantities across countries, we follow the approach of the ICP dataset and compute real aggregate GDP from the expenditure side, as $y = \sum_i p_i^{US} c_i$ using U.S. prices as the international prices.[7] To compute aggregate labor productivity in the model in each country, we divide real aggregate GDP y by the total employment allocation to manufacturing and services implied by the development accounting. For the corresponding target in the data, we use the ICP data to calculate aggregate labor productivity in each country in the manufacturing and service sectors using the employment shares implied by the development accounting.

The implications of the model for sectoral labor productivity across countries are summarized in Table 10, where we report results relative to the United States. The model results are similar to those from the development accounting. The model implies that the income elasticity of labor productivity in non-traditional services is the highest (1.17), followed by manufacturing (1.04) and traditional services (0.69). For comparison, these elasticities in the development accounting are 1.15, 1.05, and 0.67, respectively. The dispersion of productivity across countries implied by the model increases for all sectors with the value of ρ, for $\rho = 0$ the elasticities are 1.15, 1.01, and 0.66 and for $\rho = 0.5$ 1.21, 1.07, and 0.72.

The model also has implications for (nominal and real) consumption shares which can be compared to data from the ICP dataset. Figure 10 plots the real shares of consumption of manufacturing, and traditional and non-traditional services by decile. The model replicates reasonably well the patterns of consumption shares across countries. Figure 11 plots the share of non-traditional services in total services (both nominal and real) by decile. With $\rho = 0.25$ and the declining price of non-traditional services relative to traditional services

[7]We note that since international prices in the data are quantity weighted geometric averages of prices in the world, their pattern is strongly influenced by developed-country prices and in particular the U.S. price. For this reason, our results are robust to using international prices in the model instead of U.S. prices.

Table 10: Sectoral Productivity Results from the Model

	Relative Productivity	A_i m	s_T	s_N
D_1	0.03	0.02	0.13	0.02
D_2	0.04	0.03	0.18	0.03
D_5	0.16	0.06	0.53	0.19
D_9	0.67	0.54	1.09	0.70
D_{10}	0.89	0.82	1.36	0.91
Ratio D_{10}/D_1	35.8	42.1	10.3	51.6
Income elasticity	–	1.04	0.69	1.17
		(0.05)	(0.03)	(0.03)

Notes: Relative Productivity refers to aggregate labor productivity (manufacturing plus services) relative to that of the United States. A_i is labor productivity in each sector relative to that of the United States. The income elasticity is the slope coefficient from an OLS regression of log productivity on log GDP per capita across all countries in our sample. Standard errors are in parenthesis.

with income in the data, the model is consistent with the reallocation of nominal and real expenditures towards non-traditional services observed in the data. The sectoral reallocation implied by the model varies with the value of ρ, with $\rho = 0$ producing too little reallocation of consumption, whereas $\rho = 0.5$ produces more reallocation than in the cross-country data.

We also note that the Cobb-Douglas utility specification in (11) between manufacturing and total services implies that the expenditure share of services in income is constant across countries and over time. Recall that income in our model maps to total expenditures net of food or total value added net of agriculture in the data. We find some support in the data that this share does not vary strongly with GDP per capita in the cross-country data. Unlike the strong correlation between the expenditure share in services and GDP per capita of 0.59 in Figure 1, there is a much weaker correlation of 0.26 with the share of services in manufacturing and services across countries, see Figure 12. This weaker correlation arises because for poor and developing countries there is a strong reallocation away from agriculture into manufacturing and services. Since our analysis abstracts from agriculture and focuses on assessing sectoral changes in poor and developing countries, we argue the Cobb-Douglas assumption is reasonable in this context even though is counterfactual for the time series in developed countries. In the time series data for the United States, the expenditure share of services relative to manufacturing and services rises since agriculture accounts for a very small portion of total income. The fact is that there is much more reallocation from manufacturing to services in rich countries compared to poor and developing countries and this pattern in the data is difficult to reconcile with simple preferences. There has been substantial progress in the literature developing specifications of preferences that can accommodate a variety of patterns of income and substitution effects across countries (Boppart, 2014; Comin et al., 2015; Alder et al., 2018). We leave a more detailed analysis of these more complex reallocation patterns for future work.

We also derive the productivity implications of the model in the absence of the input-output structure. We recalibrate the benchmark economy assuming no intermediate inputs, $\alpha = 0$ in all sectors, and re-do the cross-country exercise using the same targets. The results of the model are consistent with those from the development accounting exercise. Without intermediate inputs the income elasticity of labor productivity in manufacturing is 1.07, 0.81 in traditional services, and 1.15 in non-traditional services. That is, as before, the largest impact of the input-output structure is to lower the dispersion of productivity in traditional services. It also makes the dispersion of productivity in manufacturing somewhat smaller and that of non-traditional services somewhat larger.

4.4 Aggregate Implications

Our analysis of relative prices has uncovered substantial variation in labor productivity in non-traditional services, a variation which is as large or larger than in manufacturing and is much larger than in traditional services. What are the aggregate productivity implications of these differences? Ultimately, the aggregate impact of sectoral variation in productivity depends on the magnitude of each sector share in the economy and how these shares change with alternative productivity levels. To assess the aggregate implications of variation in sectoral productivity levels across countries, we conduct a series of counterfactuals where we set, for each sector at a time, the productivity level in all countries to the level in the United States. In each counterfactual for manufacturing, traditional services, and non-traditional services, we report relative aggregate productivity in Table 11 along with labor productivity in each sector for deciles of the income distribution.

Setting productivity in manufacturing in all countries to the level in the United States implies a reduction in aggregate productivity disparity from 35.8-fold between the richest and poorest deciles of income to 12.4-fold. This is a reduction of 30 percent ($\log(2.9)/\log(35.8)$) in the disparity in aggregate productivity between rich and poor countries. In other words, eliminating the 42.1-fold variation in manufacturing productivity between rich and poor countries generates a reduction of 2.9-fold in the income disparity, a result that arises from the relatively small and constant share of manufacturing in the economy and the fact that manufacturing uses substantial intermediate inputs from other sectors whose productivity have not changed. Setting productivity in traditional services in all countries to the level in the United States implies a reduction in the disparity in aggregate productivity to 7.7-fold between rich and poor countries. Even though the disparity in traditional services is relatively small—a factor of 10.3 fold between rich and poor countries—the reduction in aggregate productivity disparity is 4.7-fold (a 43 percent reduction in disparity) because this sector accounts for a larger share of the economy that increases in the counterfactual, especially in poor countries, reducing the share of non-traditional services where productivity gaps are substantial. Setting productivity in non-traditional services in all countries to the level in the United States implies a reduction in aggregate productivity disparity to 4.6-fold—a 7.9-fold reduction—which represents a reduction of 58 percent in the aggregate productivity disparity. This large reduction in aggregate productivity differences arises from the substantial differences in productivity in non-traditional services—a factor of 51.6-fold

Table 11: Counterfactual Experiments on Sectoral Productivity across Countries

	Relative Productivity	m	A_i s_T	s_N
Baseline model:				
D_1	0.03	0.02	0.13	0.02
D_2	0.04	0.03	0.18	0.03
D_5	0.16	0.06	0.53	0.19
D_9	0.67	0.54	1.09	0.70
D_{10}	0.89	0.82	1.36	0.91
D_{10}/D_1	35.8	42.1	10.3	51.6
Counterfactual: manufacturing				
D_1	0.08	1.00	0.13	0.02
D_2	0.11	1.00	0.18	0.03
D_5	0.30	1.00	0.53	0.19
D_9	0.78	1.00	1.09	0.70
D_{10}	0.93	1.00	1.36	0.91
D_{10}/D_1	12.4	1.0	10.3	51.6
Counterfactual: traditional services				
D_1	0.10	0.02	1.00	0.02
D_2	0.14	0.03	1.00	0.03
D_5	0.24	0.06	1.00	0.19
D_9	0.66	0.54	1.00	0.70
D_{10}	0.80	0.82	1.00	0.91
D_{10}/D_1	7.7	42.1	1.0	51.6
Counterfactual: non-traditional services				
D_1	0.20	0.02	0.13	1.00
D_2	0.25	0.03	0.18	1.00
D_5	0.36	0.06	0.53	1.00
D_9	0.79	0.54	1.09	1.00
D_{10}	0.93	0.82	1.36	1.00
D_{10}/D_1	4.6	42.1	10.3	1.0

Notes: Each counterfactual experiment sets the gross output productivity in a sector in each country to that of the United States, i.e. $B_i^j = B_i^{US}$. Relative Productivity refers to aggregate labor productivity (manufacturing plus services) relative to that of the United States. A_i is labor productivity in each sector relative to that of the United States.

between rich and poor countries—and the substantial increase in the share of non-traditional services in poorer countries as a result of the productivity improvement. Overall, these results reinforce our findings of the importance of non-traditional services for aggregate productivity differences across countries.

Our analysis of relative prices has also emphasized the importance of heterogeneity in services, and in particular, our finding of an important set of individual service categories with a negative income gradient of relative prices. To assess the aggregate implications of this heterogeneity in the service sector and the role of the input-output structure, we conduct an experiment whereby, for each country, we eliminate differences in gross output productivity between the two types of services. In particular, in this experiment the productivity levels in both types of services in each country are those implied by the benchmark model for traditional services $B_{s_N} = B_{s_T}$. As a result, this experiment eliminates heterogeneity in services by making all services equally productive as traditional services within a country. We choose traditional services because this type of services has a positive income elasticity of the relative price as aggregate services do. We report in Table 12 the aggregate labor productivity implied by the model for five deciles of the income distribution together with relative sectoral labor productivities in the baseline model and the counterfactual with and without intermediate inputs.

The results indicate that abstracting from heterogeneity in the service sector has a substantial impact on the differences in aggregate productivity across countries since it reduces the dispersion in labor productivity in non-traditional services. For instance, whereas the ratio of labor productivity in non-traditional services is a factor of 51.6-fold in the baseline model, in the experiment this ratio is 12.4-fold. Even though in the experiment the gross output productivity is the same as in traditional services, the disparity in value added productivity in non-traditional services is larger because of intermediate inputs. Nevertheless, this relative improvement in sectoral labor productivity implies that the aggregate labor productivity

Table 12: Counterfactual Experiment, Heterogeneity in Services

	Relative Productivity	m	A_i s_T	s_N
Baseline model:				
D_1	0.03	0.02	0.13	0.02
D_2	0.04	0.03	0.18	0.03
D_5	0.16	0.06	0.53	0.19
D_9	0.67	0.54	1.09	0.70
D_{10}	0.89	0.82	1.36	0.91
D_{10}/D_1	35.8	42.1	10.3	51.6
Counterfactual:				
D_1	0.05	0.02	0.13	0.11
D_2	0.07	0.03	0.18	0.15
D_5	0.24	0.06	0.53	0.50
D_9	0.81	0.54	1.09	1.09
D_{10}	1.03	0.82	1.36	1.40
D_{10}/D_1	22.1	42.1	10.3	12.4
Counterfactual: no intermediate inputs:				
D_1	0.03	0.02	0.07	0.07
D_2	0.05	0.03	0.11	0.11
D_5	0.19	0.09	0.36	0.36
D_9	0.72	0.59	0.94	0.94
D_{10}	0.93	0.86	1.21	1.21
D_{10}/D_1	30.8	44.1	16.3	16.3

Notes: The experiment sets the gross output productivity in the non-traditional sector to that of the traditional sector in each country, i.e. $B_{s_N} = B_{s_T}$ so that there is no heterogeneity in the service sector. Relative Productivity refers to aggregate labor productivity (manufacturing plus services) relative to that of the United States. A_i is labor productivity in each sector relative to that of the United States.

disparity implied by the model between the top and bottom deciles falls to 22.1-fold from 35.8-fold, a reduction of 14 percent. For comparison, this reduction in income disparity is about half the reduction from eliminating the cross-country differences in manufacturing productivity.

Intermediate inputs play an important role in the quantitative assessment of the aggregate implications of heterogeneity in services. The aggregate impact of eliminating heterogeneity in services is magnified by the role of non-traditional services as an intermediate input in all sectors. In the absence of input-output linkages, the same experiment of eliminating heterogeneity in productivity levels within services implies a ratio of aggregate labor productivity between the top and bottom deciles of about 30.8-fold, which is a much smaller reduction in disparity compared with the intermediate-inputs case.

We conclude with the two sets of experiments that the heterogeneity in services we documented has substantial implications for aggregate outcomes, especially for poor and developing countries.

5 Conclusion

We document that many categories in services feature a falling relative price with income. We also document a substantial reallocation of expenditures in services from categories with positive income elasticities (traditional services) to categories with negative elasticities (non-traditional services) as income raises. Using a multi-sector development accounting framework extended to include an input-output structure, we uncover the importance of price heterogeneity in services for productivity implications. We find that labor productivity differences in service categories with falling relative prices with development are at least as large as those in manufacturing and much larger than those service categories with a rising relative price with development.

Our evidence points to substantial differences in the relative price behavior across service categories and that these differences matter for productivity inferences. In particular, we show large aggregate productivity losses due to the heterogeneity in services in poor countries. Our analysis does not address, however, the origins of observed differences in relative prices. We leave the identification of the fundamental characteristics of individual service categories that determine their productivity and price behavior to future research. For instance, it would be interesting to explore the extent to which differences in skill intensity across disaggregated service categories relates to differences in relative prices across countries, along the lines of the analysis in Buera and Kaboski (2012) for the United States. We have also only studied the reallocation patterns of expenditure shares among aggregated categories of services. In order to identify potential sources of variation over time and across countries, it may be interesting to study the more disaggregate implications of reallocation within services. Similarly, it may be useful to study the disaggregate expenditure patterns across households with different income levels in a country.

One area of particular interest is the role of international trade (or the lack thereof) in services in accounting for relative prices. While the contribution of services to overall trade remains relatively low (around 10 percent of world output), it has substantially increased over time. International trade can play a role in how relative prices behave in the cross-country data, either by providing competitive pressures in the domestic market or by providing cheaper intermediate inputs. Increased trade in services and more years of ICP detailed price data can provide an opportunity to assess the role of trade on relative price facts and sectoral productivity.

We also think there is an interesting distinction between the possibility of trade in services and actual trade-ability as many of the service industries that we have shown have large negative income elasticities of relative prices are in practice often restricted from international competition, such as transportation, communications, financial services and insurance.

Importantly, we found that the process of development involves a reallocation to these non-traditional services which, in turn, hinges on productivity in those sectors. Facilitating development thus requires solving the productivity problem in non-traditional services in developing countries. However, improving productivity in these industries may require policy reforms that are more complex than the typical "openness-to-trade" recipe advocated by many international organizations since many non-traditional service categories, while tradeable in principle, are plagued in practice in many countries by a heavy burden of restrictions and regulations.

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A Data Sources and Definitions

A.1 ICP Data

The International Comparison Program (ICP) provides parity and expenditure data for 129 categories for 146 countries for the year 2005. The parity for each category (basic heading) is generated by the ICP based on detailed price data collected in each country. The parity pp_{ij} for each basic heading i, $i = 1, ..., m$, in country j, $j = 1, ..., n$, is expressed in units of currency of country j to the numeraire currency (the U.S. dollar). The ICP also provides expenditure data, in national currency units, for each basic heading in each country, E_{ij}. The expenditure data are obtained from national account systems. Expenditure over all basic headings aggregates to GDP. At the basic heading level, parities allow expenditure data to be converted into a common currency, making it comparable across countries. We convert each country's expenditure for a basic heading to U.S. dollars by computing notional quantities, defined as $q_{ij} = E_{ij}/pp_{ij}$.

The ICP aggregates basic heading parities and expenditures into higher levels of aggregation (such as GDP) using the Èltetö, Köves, and Szulc (EKS) method. Although the EKS is considered the most appropriate method to compare the different aggregates of the GDP across economies, the expenditures by aggregate are not additive to higher levels of aggregation. We aggregate the detailed ICP data using the Geary and Khamis (GK) method, which produces additive results. For the purpose of our paper, additive consistency is an important property because it enables the calculation of shares (e.g., the share of real services in real GDP) and their comparison across countries.[8]

The GK method delivers a set of international prices, π_i for each basic heading i. The valuation of country j's output in international prices is then $RGDP_j = \sum_{i=1}^{m} \pi_i q_{ij}$. The

[8]Note that computing GDP in country j in a common currency by simply adding up notional quantities for all basic headings would use the relative prices between basic headings that prevailed in the United States, the numeraire country. Hence, the result would not be invariant to the base country.

international price for heading i is defined as

$$\pi_i = \frac{\sum_{j=1}^{n} \frac{pp_{ij}}{PPP_j} q_{ij}}{\sum_{j=1}^{n} q_{ij}}, \tag{14}$$

where PPP_j is the purchasing power parity over GDP for country j, given by

$$PPP_j = \frac{GDP_j}{RGDP_j}, \text{ where } GDP_j = \sum_{i=1}^{m} E_{ij}. \tag{15}$$

The international prices are defined so that they imply a purchasing power parity over GDP for each country that is consistent with the prices. We obtain the international prices π_i by iterating on equations (14) and (15), given an initial guess for PPP_j. At each iteration we scale the PPP's so that the PPP for the United States is 1 and we assume that the parity for net exports and net expenditures of residents abroad is 1.

After computing international prices, we restrict the data set to countries with more than one million inhabitants in 2005. Our restricted data set covers 130 countries and in this sample the range of income differences is quite large, for instance, the ratio of top to bottom deciles of the income per capita distribution is 49.2-fold.

A.2 Detailed GDP Data for the United States

For total services (Figure 4, top panel), we use the series for GDP and services from NIPA Tables 1.2.5 (Gross Domestic Product by Major Type of Product, billions of dollars) and 1.2.6 (Gross Domestic Product by Major Type of Product, chained dollars) from the Bureau of Economic Analysis. These tables cover the period 1929-2016. These tables decompose GDP into goods, services (which includes government consumption expenditures), and structures. Between 1950 and 2016, the sum of the real (chained-dollar) series for goods, services, and structures always differs from real gross domestic product by less than 6 percent (and by less than 4 percent in 48 years). Therefore, we treat these aggregates as approximately additive between 1950 and 2016 and we compute the real share of services in gross domestic product as the ratio of real (chained-dollar) services to real GDP.

To construct series for traditional and non-traditional services (Figure 4, bottom panel), we use NIPA Tables 1.5.5 (Gross Domestic Product, Expanded Detail, billions of dollars), 1.5.3 (Gross Domestic Product, Expanded Detail, quantity indexes), 1.5.4 (Price Indexes for Gross Domestic Product, Expanded Detail), 2.4.5 (Personal Consumption Expenditures by Type of Product, billions of dollars), 2.4.3 (Personal Consumption Expenditures by Type of Product, quantity indexes), and 2.4.4 (Price Indexes for Personal Consumption Expenditures by Type of Product) from the Bureau of Economic Analysis. These tables cover the period 1929-2015. We divide services into traditional and non-traditional by matching the traditional and non-traditional service categories in the ICP data to the available categories in the NIPA tables. The traditional service categories are government consumption expenditures (Table 1.5.5, categories 55, 58, and 61), housing (Table 2.4.5, category 50), health care (Table 2.4.5, category 60), education services (Table 2.4.5, category 100), personal care and clothing services (Table 2.4.5, category 105), and other recreational services (Table 2.4.5, category 80).

We compute real (chain-dollar) series for traditional services and non-traditional services by chain-aggregating the corresponding component categories, see Whelan (2002). Between 1950 and 2015, the sum of real traditional and non-traditional services always differs from real total services by less than 3.5 percent (and by less than 2.5 percent in all but three years). Therefore, we treat these aggregates as approximately additive over this period and we compute real shares of traditional and non-traditional services in total services.

We trend the series for nominal and real GDP, expenditures in services, traditional services and non-traditional services using the Hodrick-Prescott filter (with smoothing parameter 100).

We compute implicit price deflators for each aggregate as the ratio of the current-dollar value of the series to its corresponding chained-dollar value, multiplied by 100.

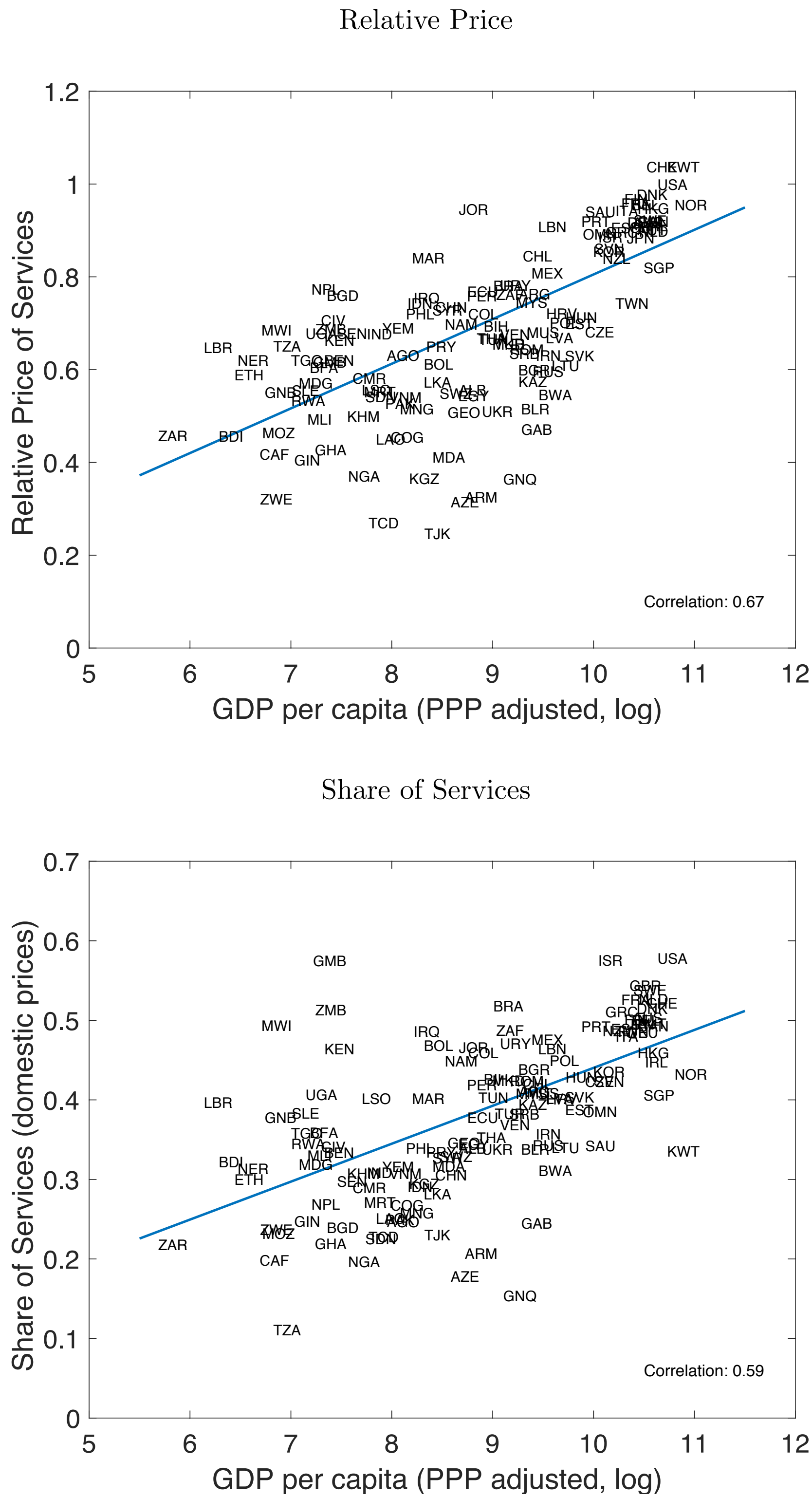
A.3 World Input-Output Database

We use the national input-output tables from the World Input-Output Database, see Timmer et al. (2012). These tables are available yearly, from 1995 to 2011, for 40 countries. The countries covered are: Australia, Austria, Belgium, Bulgaria, Brazil, Canada, China, Cyprus, Czech Republic, Germany, Denmark, Spain, Estonia, Finland, France, United Kingdom, Greece, Hungary, Indonesia, India, Ireland, Italy, Japan, Korea, Lithuania, Luxembourg, Latvia, Mexico, Malta, Netherlands, Poland, Portugal, Romania, Russia, Slovak Republic, Slovenia, Sweden, Turkey, Taiwan, and United States. These tables use a 35 by 35 industry classification. We aggregate these 35 industries into 4: manufacturing, traditional services, non-traditional services, and other. The aggregation is the following (NACE codes):

- manufacturing: D17-37
- traditional services: K70, L, M, N, P
- non-traditional services: G, H, I, J, K71-74, O
- other: A+B, C, D15-16, E, F

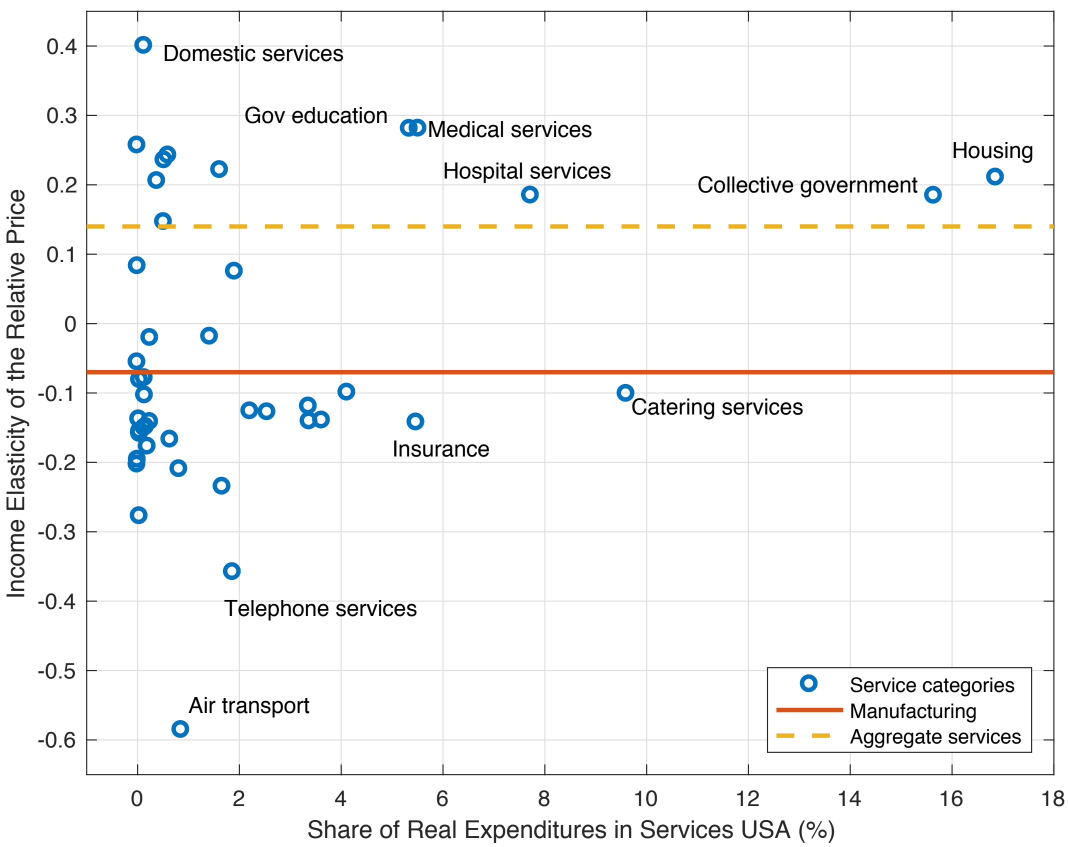
For the baseline framework, we restrict the economy to three sectors (manufacturing, traditional services, and non-traditional services). For each of these sectors we compute α as the share of intermediate inputs from these three sectors in gross output net of inputs from "other." The share of intermediate input i used in sector j, φ_{ij}, is computed as the share of inputs from sector i in inputs from the three sectors used in sector j.

Figure 1: Total Services across Countries



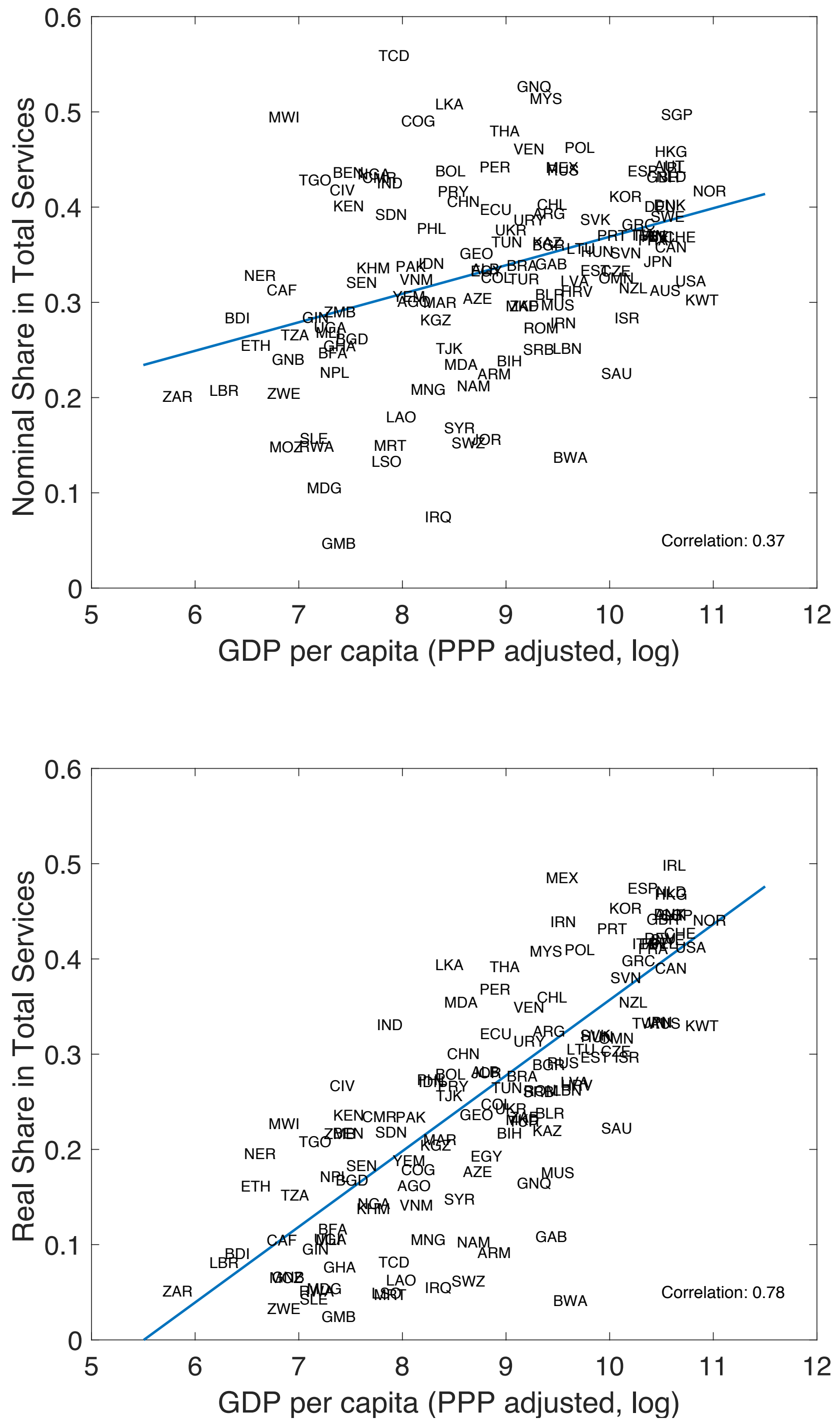
Notes: Data for 2005 from ICP. The relative price of services refers to the PPP price of total services relative to the PPP price of GDP. The share of services refers to nominal expenditures in total services relative to nominal GDP.

Figure 2: Income Elasticity of Relative Prices



Notes: Data for 2005 from ICP. The elasticity is the slope coefficient of an OLS regression between the log of the price of a given category relative to the price of GDP on a constant and the log of real GDP per capita.

Figure 3: Non-traditional Services across Countries

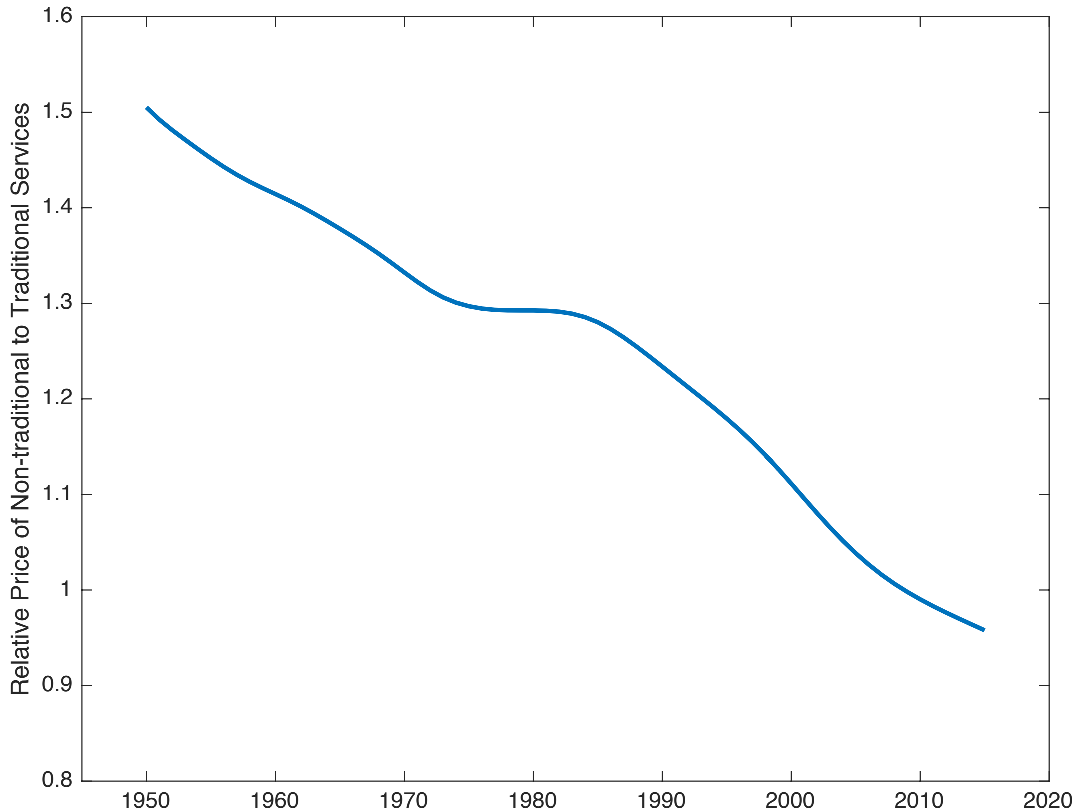


Notes: Data for 2005 from ICP. The nominal (real) share of non-traditional services refers to nominal (real) expenditures in non-traditional services relative to nominal (real) expenditures in total services. Nominal refers to expenditures in domestic prices and real refers to expenditures at international prices.

Figure 4: Services in the United States

Notes: Data from the BEA. Authors' calculations. The data are H-P trended, see appendix A.2.

Figure 5: Relative Price of Non-traditional to Traditional Services in the United States

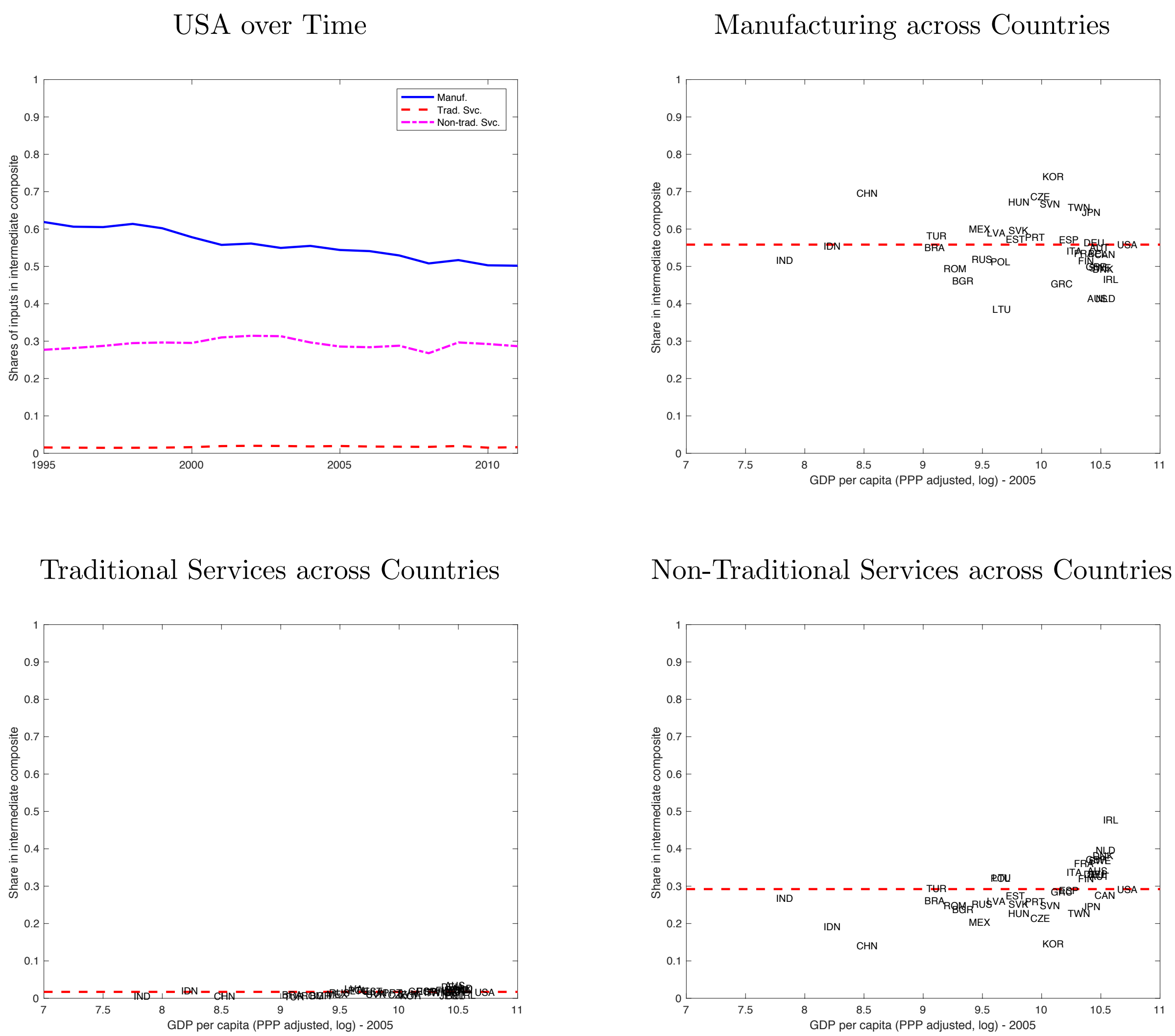


Notes: Data from the BEA. Authors' calculations. The data are H-P trended, see appendix A.2.

Figure 6: Share of Intermediate Inputs over Time and across Countries

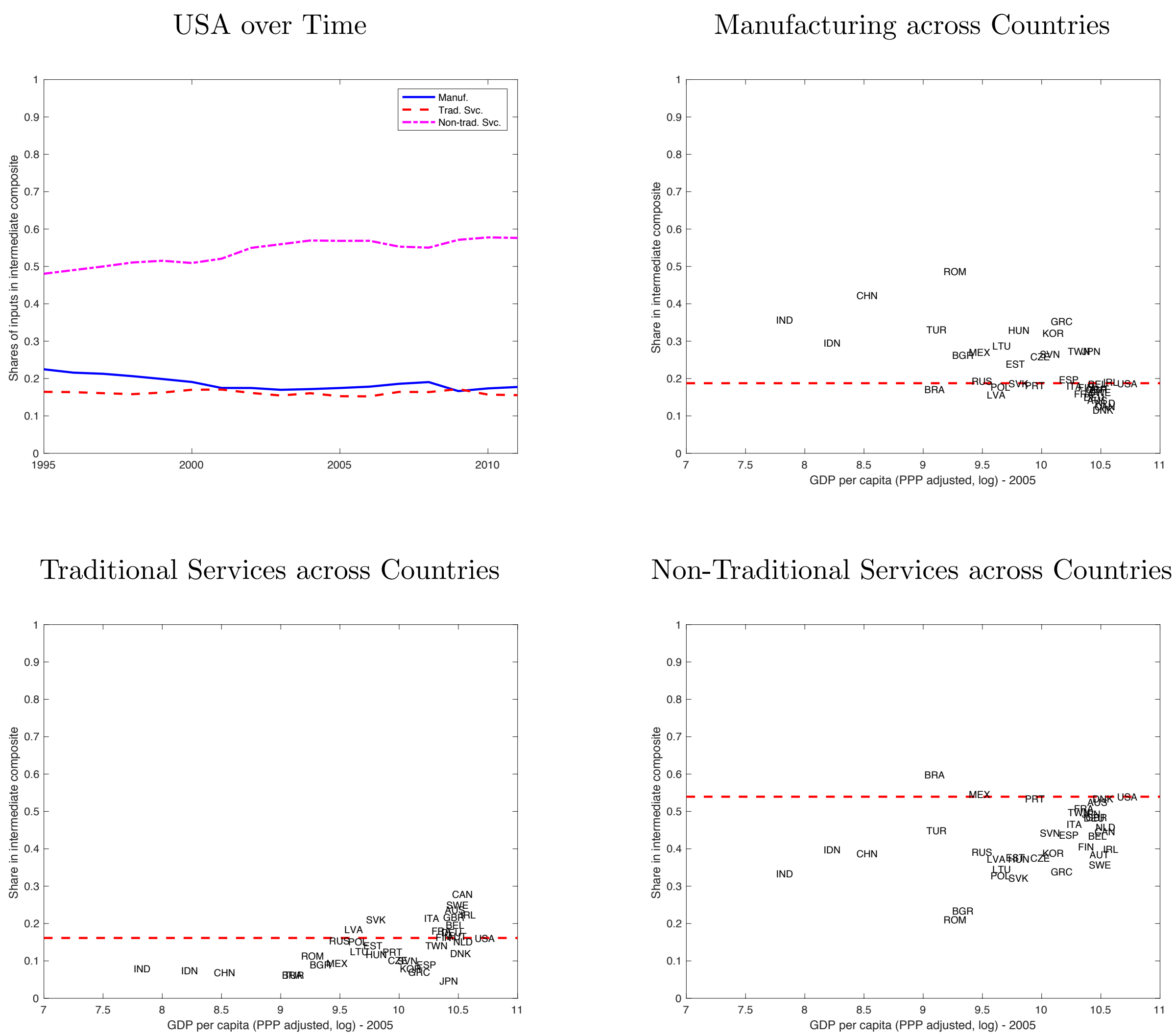
Notes: The panels with shares across countries plot the time series average for each country. In these panels the red-dotted line marks the time series average for the United States.

Figure 7: Share of Inputs in Composite used in Manufacturing



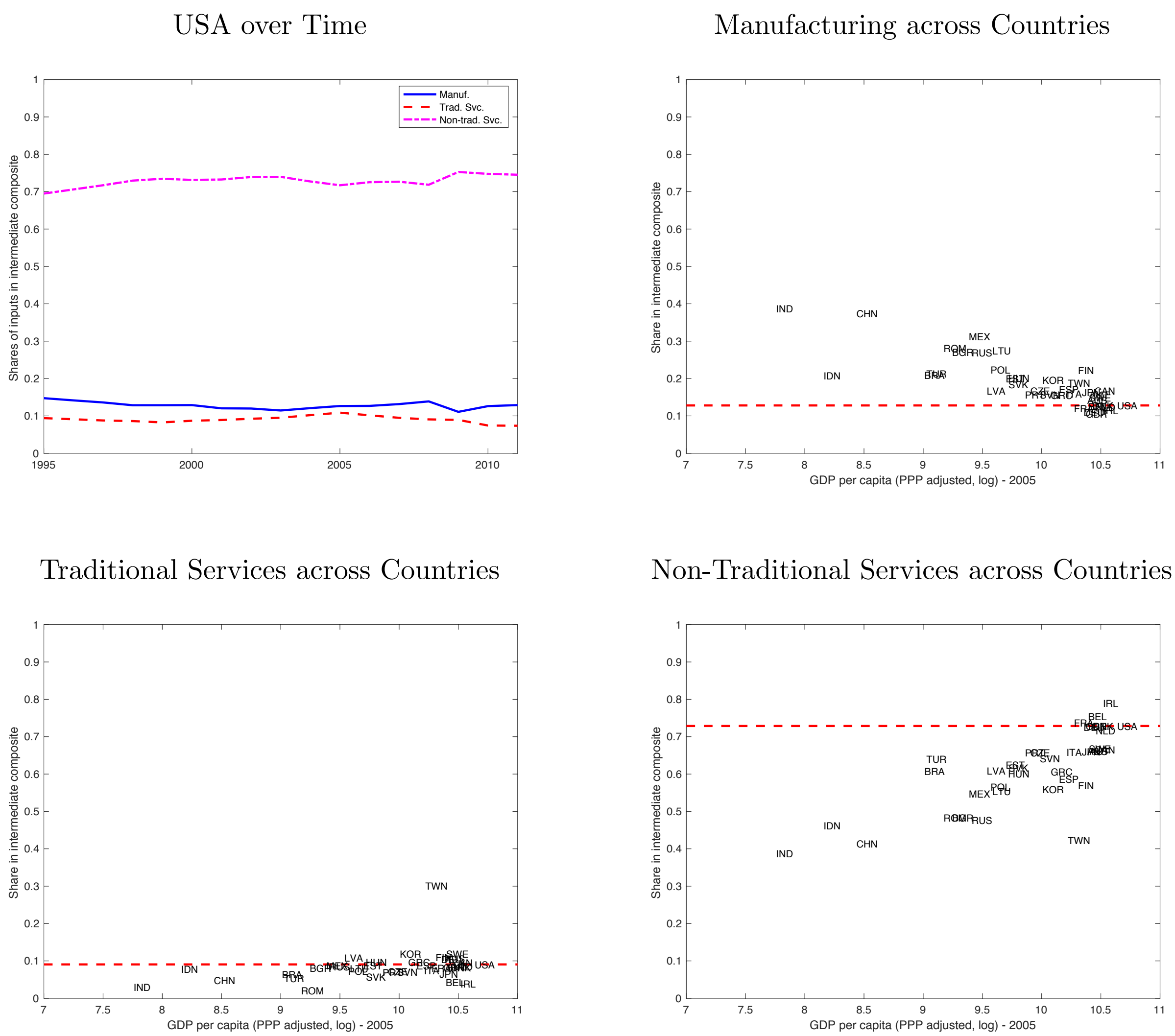
Notes: The panels with shares across countries plot the time series average for each country. In these panels the red-dotted line marks the time series average for the United States.

Figure 8: Share of Inputs in Composite used in Trad. Services



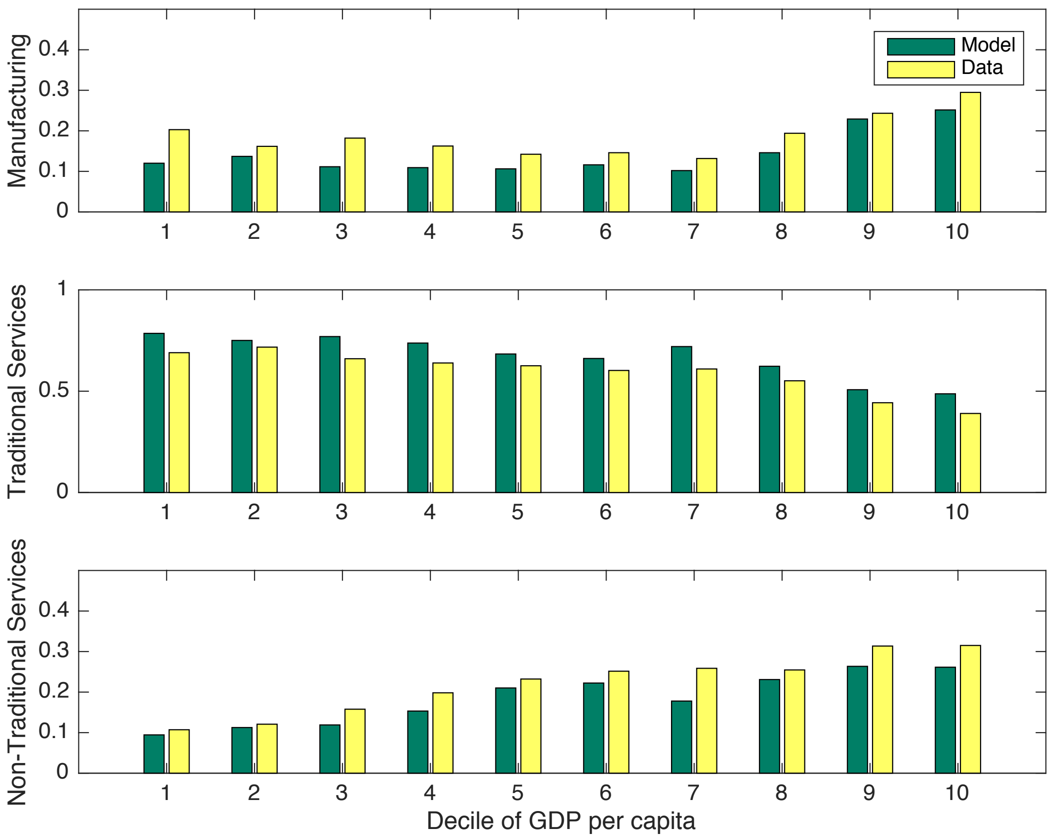
Notes: The panels with shares across countries plot the time series average for each country. In these panels the red-dotted line marks the time series average for the United States.

Figure 9: Share of Inputs in Composite used in Non-Trad. Services



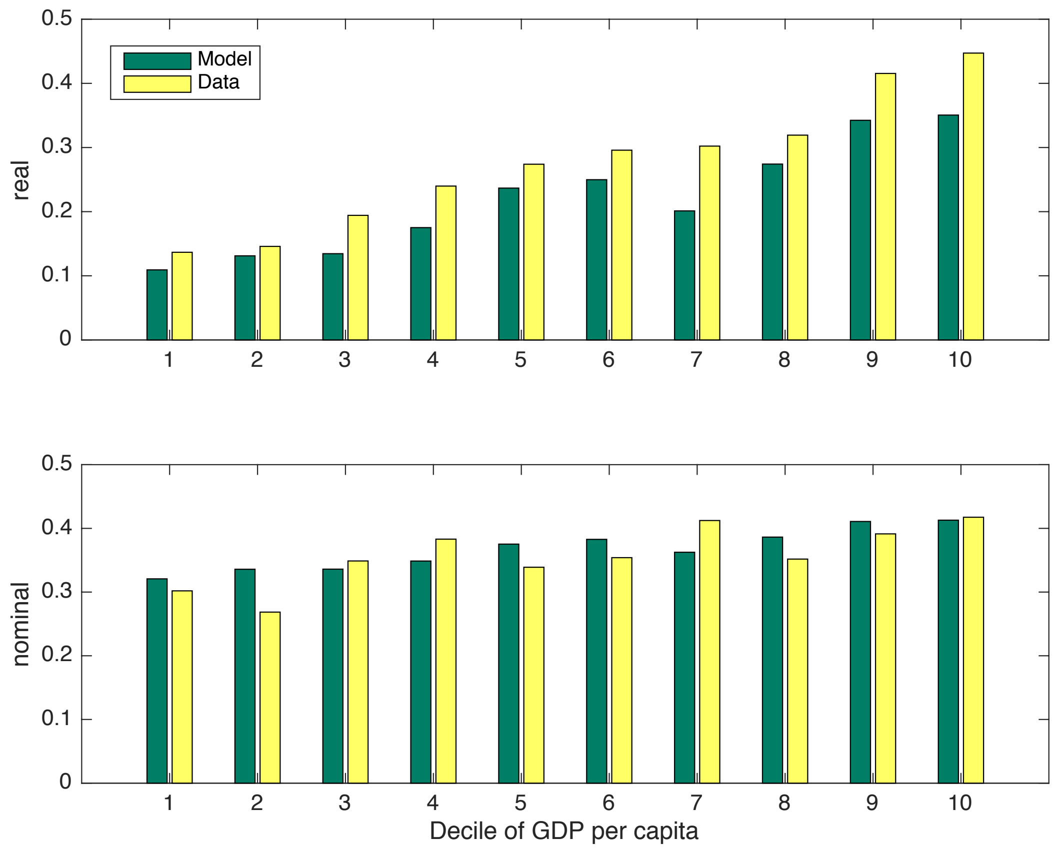
Notes: The panels with shares across countries plot the time series average for each country. In these panels the red-dotted line marks the time series average for the United States.

Figure 10: Real Shares of Consumption



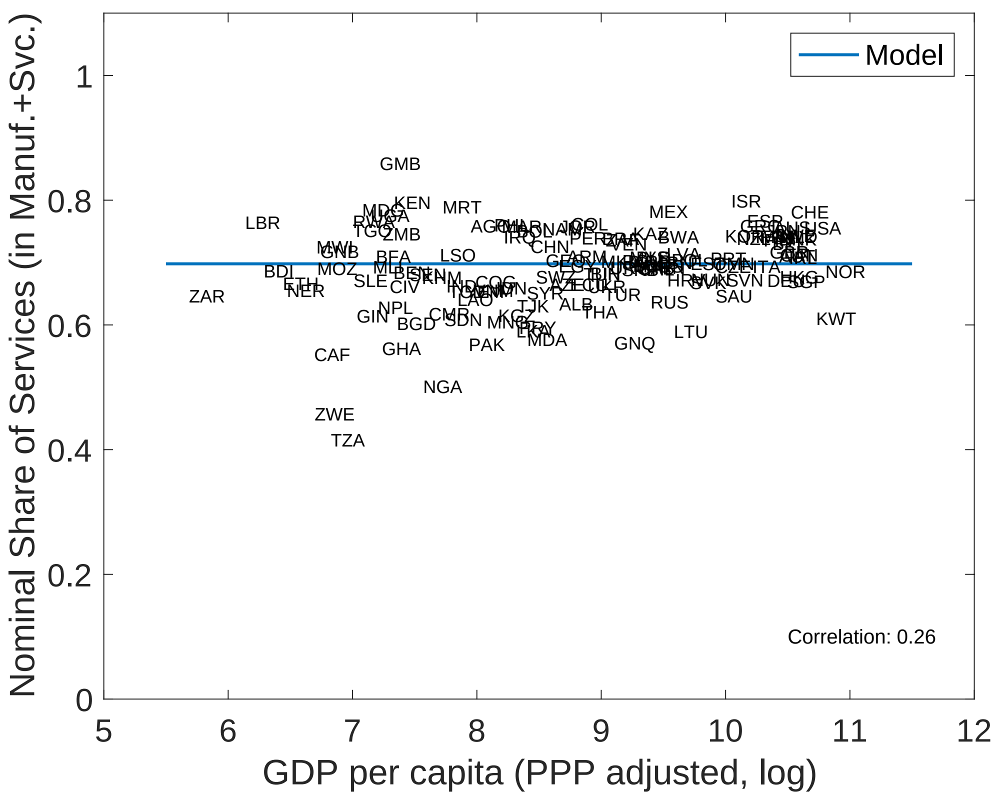
Notes: Data for 2005 from ICP. The real share of consumption refers to real expenditures in each sector relative to real total expenditures. Real refers to expenditures at international prices.

Figure 11: Share of Non-Traditional Services in Total Services



Notes: Data for 2005 from ICP. The nominal (real) share of non-traditional services refers to nominal (real) expenditures in non-traditional services relative to nominal (real) expenditures in total services. Nominal refers to expenditures in domestic prices and real refers to expenditures at international prices.

Figure 12: Nominal Share of Services Expenditures in Manufacturing and Services



Notes: Data for 2005 from ICP. The share of services refers to nominal expenditures in services relative to manufacturing and services.