CONSUMPTION IN ACTION: INFLATION SPILLOVERS in the EUROPEAN UNION

by

Beril Ünal

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Abstract

Economists and policymakers focus on aggregate inflation measures, such as headline and core inflation. In this thesis, we argue that the inflation spillovers across consumer good sub-categories are as important as their direct contributions to the aggregate inflation measures. We identify and characterize the spillovers among 12 major consumption groups by applying Diebold-Yilmaz connectedness index methodology. We utilize the disaggregated Harmonized Index of Consumer Prices data of European Union member countries, 1996-2017. We estimate the within-country inflation connectedness across 12 groups statically using the data for the full-sample, and dynamically with the rolling-window estimation of 60 months. We observe resembling full-sample networks among 12 groups, which indicates similar inflationary connectedness due to similarities in consumption patterns. The countries experienced different inflationary behavior mostly due to national policy shocks. The rolling-window estimation enables us to trace the connectedness throughout the sample, and we are able to pinpoint the national policy implementation dates. We also estimate the within-group inflation connectedness across EU member countries, to reveal its international aspect. International connectedness increases for Alcohol&Tobacco, Recreational&Cultural Activities and Restaurants&Hotels, positively responding to policy harmonization and developments in openness to trade. We argue that harmonization efforts in policy-making will further increase the inflation connectedness across EU.

Keywords: Consumer price inflation, Inflation connectedness, Spillovers, Vector autoregression, Forecast error variance decomposition, Network relations, European Union.

Özet

Ekonomistler ve politika belirleyiciler manşet ve çekirdek enflasyon gibi toplam enflasyon ölçütlerine odaklanır. Bu tez çalışmasında, tüketici malları alt kategorileri arasındaki enflasyon yayılmalarının, bu kategorilerin toplam enflasyon ölçütlerine doğrudan katkıları kadar önemli olduğunu iddia ediyoruz. Diebold-Yılmaz Bağlanmışlık Endeksi yöntemini kullanarak 12 temel tüketim grubu arasındaki yayılmaları saptadık ve karakterize ettik. Avrupa Birliği (AB) üyesi ülkeler için bölümlere ayrılmış Armonize Tüketici Fiyatları Endeksi kullanıyoruz, 1996-2017. 12 grupta ülke içi enflasyon bağlanmışlığını tüm veri ile durağan olarak ve 60 aylık kayan pencereler ile devingen olarak hesaplıyoruz. Tam örneklem sonucunda 12 grup arasında, tüketim şekillerindeki benzerliklerden ötürü benzer enflasyon bağlanmışlığı belirten şebekeler gözlemliyoruz. Ülkeler çoğunlukla ulusal politika şokları nedeniyle farklı enflasyon davranışları yaşamıştır. Kayan pencere analizi örnek boyunca bağlanmışlığı izlememizi sağlar ve böylece ulusal politika uygulama tarihlerini belirleyebiliriz. Aynı zamanda, AB üyeleri arasında grup içi enflasyon bağlanmışlığını tahmin ediyoruz. Alkol ve Tütün, Eğlence ve Kültürel Etkinlikler ve Restoranlar ve Oteller için uluslararası bağlanmışlığın zaman içinde arttığını ve ticaret açıklığı gelişmelerine olumlu yanıt verdiğini görüyoruz. Politikaları uyumlaştırma çabalarının AB çapında enflasyon bağlanmışlığını daha da artıracağını öngörüyoruz.

Anahtar Kelimeler: Tüketici enflasyonu, Enflasyon bağlanmışlığı, Yayılma, Vektör otoregresyon, Kestirim hatası varyans ayrıştırması, Şebeke ilişkileri, Avrupa Birliği.

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1 Introduction

Central banks rely heavily on core inflation measures to gauge the effect of monetary policy implementations on inflation, as these measures are assumed to be free of exogenous price changes in world prices of food, energy, tobacco and gold. However, once we consider that the price changes in any consumption good might have indirect spillover effects on the price of other goods, using core inflation measures to evaluate monetary policy effects would not be fully informational. Even though food, energy, gold and some other subcategories are excluded from the core inflation calculations, their price changes will have indirect effects on the prices of other consumption goods. For instance, an increase in food prices today may affect the core inflation through its spillover effects on the prices of restaurants and hotels in the subsequent months.

The direct contribution of price changes for the subcategories of goods and services on the headline inflation is measured by multiplying the original change with the weight of the respective category in the consumption basket. For example, to calculate the direct contribution of the Food and Beverages subcategory in 2016 one needs to multiply the price change for this subcategory (1.05%) with its weight in the consumption basket (16.58%) and obtain the contribution (0.17%). Core inflation measures are computed similarly by only excluding food and/or oil prices. However, such an approach ignores the possibility of subcategory price changes' indirect contribution to the headline inflation. The aim of this study is to emphasize that one needs to measure the indirect contribution of the subcategory price changes on the headline inflation, which takes place through the spillover effects on prices of other subcategories. In order to design an effective monetary policy, the indirect contribution of subcategory price changes must be taken into account along with their direct contribution.

For all these reasons, macroeconomists and policymakers can make use of inflation spillover measures across groups that eventually generate indirect impact and momentum on headline inflation. Diebold-Yilmaz Connectedness Index (DYCI) methodology, which was proposed and developed further in a series of contributions by Diebold and Yilmaz ([Diebold and Yilmaz, 2009], [Diebold and Yilmaz, 2012], [Diebold and Yılmaz, 2014]), is the most suitable econometric framework to measure price shock spillovers across subcategories. A flexible and simple methodology, DYCI is commonly used to analyze how the shocks to time series variables, such as asset returns or volatilities, or industrial production measures, spill over to other variables. The fact that it can be used in financial markets as well as in macroeconomic framework reflects its flexibility and at the same time its usefulness. For that matter, it can easily be adopted to the analysis of the connectedness among prices of consumption subcategories in any country.

Within the framework of this study, we apply DYCI framework to prices for major subcategories, such as Food & Beverages, Clothing & Footwear, Transportation, Housing expenses, Education, Health, Restaurants & Hotels, and Recreational & Cultural Activities, in European Union member states. Since low and stable inflation is a precondition of entry to the union, and with the commonality of monetary policy decisions, the European Union member states are attractive to work on. The inflation connectedness analysis among the subcategories will allow us to show how the network relations among these subcategories are formed. Also, we study the connectedness across EU member countries for every subcategory. This analysis reveals the international characteristics of different consumption goods. As the DYCI framework allows dynamic analysis, we are able to analyze how the inflation connectedness within the consumption basket changes over time. Also, we track the across-EU connectedness throughout the sample. To the best of our knowledge, there is no work that looks at the inflation process from this angle.

The remainder of the study is organized as follows. Section two presents the literature on disaggregated inflation measures. Section three summarizes the dataset we used to conduct our analysis. Section four describes the methodology. Sections five and six present the results of the static and dynamic Diebold-Yilmaz Connectedness analyses, respectively. The final section concludes the study.

2 Literature Review

2.1 Inflation Dynamics

The goal of the monetary policies implemented by central banks is to stabilize the overall prices by increasing or decreasing the aggregate demand. The purchasing power of the representative household decreases rapidly with high inflation, i.e. high increase in overall price level. That is why macroeconomic policy-making primarily targets price stability. The headline inflation is measured by the changes in the Consumer Price Index (CPI), and is reported monthly and closely followed publicly. Variability in inflation is undesired, simply because it interferes with the economy's efficient operation. However, supply-side factors such as drought or increase in global commodity prices cannot be controlled by central banks. In such incidents, one should not anticipate the monetary policy aiming at headline inflation to be efficient. For this reason, central banks have developed and used core inflation measures, as firstly suggested by [Gordon, 1975], focusing at non-food and non-energy subcategories. However, the potential correlation between the components are not taken into account when calculating core inflation measures.

The transmission of price shocks are due to two channels: supply and demand. To see the effects on demand side, the implications derived in the "habit formation" literature is of high importance. According to this theoretical framework, consumer demand is determined by previous consumption levels, namely consumption commitments ([Campbell and Cochrane, 1999] and [Ravn et al., 2006]). The authors add to the literature by correcting the canonical model of consumption where there is a composite consumption good that is perfectly adjustable. Relevant examples are subcategories such as housing expenses and education spending, which are not responsive to moderate-level income shocks. Under deep habits, the demand function faced by individual producers depends on past sales, hurting the previously assumed responsiveness of the supply side as well. [Chetty and Szeidl, 2007] implement the model for different cases and also discover consumption commitments' relation to risk preferences. It is shown that habits amplify risk aversion in the case of small and moderate level income shocks, e.g. sickness or temporary loss of job. In those cases, consumers cut back on their consumption on the categories which they do not face adjustment costs, such as food. To be able to pay their rents and afford the gas for their car, households cut back on their food consumption more heavily compared to the estimated levels from the canonical model. There, households do not have separate groups where they have different levels of commitments, which is unrealistic.

The literature going beyond the headline inflation has mainly focused on the food and non-food subcategories. It is widely observed that the consumption basket of the average household in an underdeveloped country is comprised of food and beverages between 30% and 60%. This ratio is between 20% and 40% in emerging markets, whereas in many developed countries, it is well below 20%. This difference gained attention from researchers and the persistence of food and beverage price increases in Sub-Saharan Africa (SSA) economies has been investigated by [Alper et al., 2016]. Heavy reliance on food and beverages in those countries magnify the importance of this persistence and volatility. The paper shows that in SSA, the lower persistence in food inflation after 2009 is closely related to more efficient monetary policies. The authors mention that since the households in developed economies consume more on entertainment and culture, education, health and durables, those subcategories are expected to have stronger indirect effects on other subcategories. However, this subject is left for future research.

A recent work by IMF economists ([Furceri et al., 2016]) focuses on the global food prices and their effects on domestic inflation levels in advanced economies and emerging markets. The authors evaluate volatility of global food prices since 1960s until today, and show that its effect on domestic inflation levels has been decreasing with time. Additionally, emerging market economies are more heavily affected from the movements in global food prices relative to the advanced economies. This is expected since most developing countries rely more on agriculture rather than industrial sectors. As the IMF economists also emphasize, this is an additional channel that amplifies the importance of food prices on domestic inflation levels in emerging markets.

2.2 European Union Inflation Dynamics

The closest paper in the literature to our study is [Hałka and Szafranek, 2016]. The authors exploit a VAR model for the disaggregated consumer price inflation in Czech Republic, Poland and Sweden. They utilize the Harmonized Index of Consumer Prices (HICP) and investigate the spillovers of headline, core, non-energy goods and services inflation. Their study shows that the Euro Area is a net shock transmitter throughout the sample, which is sensible. Unlike our study, they focus on the spillovers in a specific subcategory among three countries. However, they do not investigate the spillovers among those subcategories, neither within nor across countries.

Exchange rate is frequently referred to as an important determinant of inflation, especially for small open economies. Two years after the Central Bank of Turkey (CBRT) adopted inflation targeting, [Kara and Öğünç, 2008] investigates the exchange rate pass-through to inflation. They attribute the slowing and weakening exchange rate pass-through to domestic inflation mainly to the success of inflation targeting regime. This paper is important since it shows the importance of monetary policies on inflation dynamics and suggests a direction for our study.

Economists at the CBRT use CPI at disaggregated level to uncover the effect of one percent depreciation in domestic currency on inflation. [Ozmen et al., 2017] employs an extended VAR model for 152 subcomponents of Turkey's Consumer Price Index. The paper is a first attempt in focusing on the components of Turkish households' consumption basket rather than the headline inflation. However, the authors did not use any of the selection and shrinkage methods in such a large VAR model. This harms the reliability of the results. Moreover, the authors observe that the 95% confidence intervals around impulse response coefficients mostly include zero. To overcome this problem, they propose a rule of thumb and assess the responses that are 75% positive as being positively affected by a shock in foreign prices. This application takes a sideway from the interpretations that economists have agreed on and exploited since [Sims, 1980].

Our paper adds to the literature by going beyond the headline inflation and emphasizing that, the indirect contribution of subcategory price changes to the headline inflation can be as important as their direct contributions. Even when the central banks monitor and target the core inflation measures, neglecting the spillover effects may cause deviations from the target. These spillover effects will be identified and quantified in this paper, aiming at more effective monetary policy-making. Moreover, our approach that closely aligns with network theory will enable the comparison of different economies' inflation connectedness.

3 Data

Inflation is one of the most carefully monitored macroeconomic indicators by the investors and consumers. We are interested in the price changes that the consumers face at disaggregated level. As an attempt to uncover the spillover effects among different consumption groups, we consider the breakdown of Consumer Price Index into 12 subcategories by purpose of consumption. The statistical agencies at every country collect consumption information from the households with Household Expenditure Surveys. These are used in determining the weights of individual items in the overall representative consumption basket. Prices of individual goods are collected frequently (varying from weekly to monthly) and multiplied by their weights to obtain the Consumer Price Index for each country. The regional statistics, such as the CPI for EU28, are calculated for a representative basket of goods and services for the EU28. The classification of the items follow COICOP/HICP: adapted version of the Classification of Individual COnsumption by Purpose (COICOP) developed by the United Nations Statistics Division. The classification aims at collecting data for individual consumption expenditures incurred by the households, non-profit institutions serving households and general government. Eurostat reports the indices for European Union member countries and the data is readily available online [Eurostat ref here]. The breakdown is given in Table 1.

We expect to answer the following questions by studying this dataset: How much of consumption group i of one country's future uncertainty (at horizon H) is due to shocks arising not with that country's consumption group i, but rather with other groups? Are component-specific shocks important determinants of co-movements? Since inflation linkages are likely to change over time, how will the time variation in connectedness be?

Table 1: Breakdown of HICP according to the Purpose of Consumption

Abbreviation	**Major Group by Purpose of Consumption**
FoodBev	Food & Non-Alcoholic Beverages
AlcoholTobacco	Alcoholic Beverages & Tobacco
ClothingFootwear	Clothing and Footwear
HousingExp	Housing, Water, Electricity, Gas & Other Fuels
HouseEquip	Furnishings, Household Equipment & House Maintenance
Health	Health
Transport	Transport
Comm	Communication
RecrCulture	Recreation & Culture
Education	Education
RestHotels	Restaurants & Hotels
OtherGS	Miscellaneous Goods & Services

Table 2: Weights of Major Groups in the Representative Consumption Basket

Date	FoodBev	AlcTob	ClothFootw	HousExp	HousEqp	Health	Transp	Comm	RecrCult	Educ	RestHotels	OtherGS
1996	19.85	4.81	8.75	15.03	8.27	0.96	14.88	14.88	10.16	0.55	8.63	6.00
1997	20.05	4.87	8.76	15.23	8.16	0.92	14.88	14.88	10.02	0.53	8.53	5.98
1998	21.32	4.80	8.75	15.41	7.89	1.06	14.57	14.57	9.67	0.56	8.12	5.74
1999	19.14	4.80	8.30	15.82	8.22	1.03	15.29	15.29	10.17	0.55	8.44	5.88
2000	17.03	4.50	7.66	15.59	7.82	2.97	15.00	15.00	10.37	0.98	8.91	6.44
2001	16.67	4.28	7.25	15.15	7.61	3.67	14.89	14.89	10.50	0.99	9.34	6.95
2002	16.55	4.31	7.26	14.83	7.55	3.66	14.34	14.34	10.53	1.07	9.41	7.70
2003	15.92	4.29	7.20	14.58	7.42	3.65	14.57	14.57	10.50	1.10	9.69	8.07
2004	15.62	4.39	7.05	14.48	7.44	3.70	14.73	14.73	10.30	1.06	9.83	8.45
2005	15.54	4.50	7.01	14.59	7.17	3.82	14.87	14.87	10.24	1.11	9.64	8.52
2006	15.23	4.41	6.93	14.87	7.26	3.76	15.23	15.23	10.21	1.14	9.48	8.47
2007	15.30	4.38	6.62	15.14	6.98	3.78	15.23	15.23	10.29	1.14	9.59	8.46
2008	16.01	4.24	6.55	15.00	6.75	3.75	15.07	15.07	10.26	1.18	9.47	8.47
2009	15.93	4.27	6.42	15.31	6.81	3.84	14.64	14.64	10.26	1.22	9.50	8.62
2010	15.67	4.39	6.36	15.23	6.76	3.93	14.96	14.96	10.27	1.21	9.29	8.68
2011	15.73	4.53	6.39	15.54	6.52	3.93	15.16	15.16	10.12	1.24	9.09	8.58
2012	15.40	4.35	6.45	16.06	6.40	4.17	15.20	15.20	9.77	1.19	9.01	8.81
2013	15.46	4.50	6.35	15.75	6.41	4.14	15.19	15.19	9.94	1.20	9.05	8.81
2014	15.82	4.56	6.21	15.79	6.35	4.20	14.86	14.86	10.05	1.24	9.05	8.74
2015	15.61	4.55	6.07	15.84	6.27	4.40	14.72	14.72	9.99	1.31	9.15	8.89
2016	15.37	4.54	6.09	15.36	6.20	4.60	14.56	14.56	10.07	1.31	9.39	9.27
2017	15.52	4.07	6.09	15.77	6.23	4.83	15.02	3.23	9.20	1.09	9.60	9.37
AVERAGE	**16.58**	**4.47**	**7.02**	**15.29**	**7.11**	**3.40**	**14.90**	**14.37**	**10.13**	**1.04**	**9.19**	**7.95**

The Harmonized Index of Consumer Prices (HICP) aims to be representative of the developments in the prices of all goods and services available for purchase within the euro area for the purposes of directly satisfying consumer needs. It measures the overall price paid by households for a specific, regularly updated basket of consumer goods and services.

Inflation observations span 254 months, starting from February 1996 up until March 2017. The observations are not seasonally-adjusted, as we are interested in capturing the raw relation among subcategories, including seasonal changes in consumption. The countries available in the dataset are 28 EU member countries. In this study, we are mainly interested in monthly percentage changes in the HICP and its subcategories. The monthly percentage change is calculated as follows:

$$\pi_t = \big(\frac{P_t}{P_{t-1}} - 1\big) \times 100 \tag{1}$$

As motivated in Section 1, we are interested in the European Union. The political and economic union comprises 28 member states since 2013. Since Eurostat provides HICP data on candidate states before their entry, we comfortably exploit our analysis on the countries summarized in Table 3. The results are comparable thanks to the commonality in data collection and classification methods. It should be noted that only the expenditure made by households on goods or services for the direct satisfaction of individual needs or wants, is taken into account.

Table 3: European Union 28 Member Countries

ISO	Country	Year of EU entry	Eurozone	Year of Eurozone entry
AUT	Austria	1995	Y	1999
BEL	Belgium	1958	Y	1999
BGR	Bulgaria	2007	N	Transition
CYP	Cyprus	2004	Y	2008
CZE	Czech Republic	2004	N	Transition
DEU	Germany	1958	Y	1999
DNK	Denmark	1973	N	Opted out
ESP	Spain	1986	Y	1999
EST	Estonia	2004	Y	2011
FIN	Finland	1995	Y	1999
FRA	France	1958	Y	1999
GBR	United Kingdom	1973	N	Opted out
GRC	Greece	1981	Y	2001
HRV	Croatia	2013	N	2013
HUN	Hungary	2004	N	Transition
IRL	Ireland	1958	Y	1999
ITA	Italy	1958	Y	1999
LTU	Lithunia	2004	Y	2015
LUX	Luxembourg	1958	Y	1999
LVA	Latvia	2004	Y	2014
MLT	Malta	2004	Y	2008
NLD	Netherlands	1958	Y	1999
POL	Poland	2004	N	Transition
PRT	Portugal	1986	Y	1999
ROM	Romania	2007	N	Transition
SVK	Slovak Republic	2004	Y	2009
SVN	Slovenia	2004	Y	2007
SWE	Sweden	1995	N	Transition

4 Methodology

In this section, we discuss the methodological approach for measuring inflation and inflation spillovers within countries.

4.1 Diebold-Yilmaz Connectedness Measures

The Diebold-Yılmaz Connectedness Index methodology is constructed and developed in a series of papers: [Diebold and Yilmaz, 2009], [Diebold and Yilmaz, 2012], [Diebold and Yılmaz, 2014]. We follow this methodology for its intuitiveness and ease of handling. In addition to the methodology developed in the aforementioned papers, we estimate a Vector Autoregressive model with exogenous variables(VARX).

Consider the following covariance stationary N-variable VARX(p,q) model:

$$Y_t = \mu + A_1 Y_{t-1} + ... + A_p Y_{t-p} + B_1 X_{t-1} + ... + B_q X_{t-q} + \varepsilon_t \quad where \quad \varepsilon_t \sim iid(0, \Sigma)$$

where Y_t are the endogenous variables and X_t are the exogenous ones. The exogenous variables in our model are the monthly rate of changes in brent crude oil and Euro currency basket. Including these variables in our model enables us to control for the shocks hitting oil and euro.

We make sure that the variables do not follow unit root or explosive processes. Since the model is stationary, it has the following moving-average representation:

$$Y_t = \sum_{i=0}^{\infty} A_i \varepsilon_{t-i}$$

where the NxN, coefficient matrices A_i p order autoregressive process $A_i = \Phi_1 A_{i-1} + \Phi_2 A_{i-2} + \ldots + \Phi_p A_{i-p}$, with A_0 an NxN identity matrix and $A_i = 0$ for $i < 0$. We use MA representation of VAR in order to estimate the effects of shocks to variable x_i to the forecast of variable x_j for $i, j = 1, 2, .., N$. The connectedness is defined as fraction of H-step-ahead error variances in forecasting x_i due to shocks x_j for all i, j. Also, a variable's own variance share is defined as the fraction of H-step-ahead error variances in forecasting x_i due to x_i.

Variable j's contribution to variable i's H-step-ahead generalized forecast error variance, $\theta_{ij}^g(H)$, is calculated by the following formula

$$\theta_{ij}^{g}(H) = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} (e_i' A_h \Sigma e_j)^2}{\sum_{h=0}^{H-1} (e_i' A_h \Sigma A_h' e_i)}, \quad H = 1, 2, ...$$

where σ_{jj} is the standard deviation of the error term for the j^{th} equation, Σ is the covariance matrix for the error vector ε and e^i is the selection vector with one as the i^{th} element and zeros otherwise.

The upper-left block is called as the "variance decomposition matrix", and denoted as $D^H = [d_{ij}^H]$. The table consist of the variance decomposition matrix combined with the right-most column representing the row sums, and the bottom row representing the column sums. The bottom-right element is the grand average for $i \neq j$, or as the authors define, "total system-wide connectedness".

We normalize each entry of the variance decomposition matrix, since the sum of each row is not necessarily equal to one and we cannot draw conclusions due to different scales of the impulse responses. The rationale for normalization is for interpretation purposes, as we are interested in the relative contribution of a single off-diagonal entry with respect to the row's total sum. The procedure is performed by dividing each entry by the corresponding row sum,

$$\tilde{\theta}_{ij}^{g}(H) = \frac{\theta_{ij}^{g}(H)}{\sum_{j=1}^{N} \theta_{ij}^{g}(H)}$$

It is worthwhile to note that we follow [Diebold and Yılmaz, 2014] where the results are invariant to ordering. The authors follow [Koop et al., 1996] and [Pesaran and Shin, 1998] to obtain the generalized forecast error variance decompositions. Lastly, we obtain the four D-Y connectedness measures by using the normalized entries of the variance decomposition matrix.

The total connectedness, $C(H)$, a *system-wide* connectedness measure, as

$$C(H) = \frac{\sum_{\substack{i,j=1 \\ i \neq j}}^{N} \tilde{\theta}_{ij}^{g}(H)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ij}^{g}(H)} = \frac{\sum_{\substack{i,j=1 \\ i \neq j}}^{N} \tilde{\theta}_{ij}^{g}(H)}{N}$$

The total directional connectedness received by variable i from all other variables, $C_{i\leftarrow\bullet}$ (from connectedness), is defined as

$$C_{i\leftarrow\bullet} = \frac{\sum_{\substack{j=1\\j\neq i}}^{N} \tilde{\theta}_{ij}^{g}(H)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ij}^{g}(H)} \times 100 = \frac{\sum_{\substack{j=1\\j\neq i}}^{N} \tilde{\theta}_{ij}^{g}(H)}{N} \times 100$$

The total directional connectedness transmitted by variable i to all other variables, $C_{\bullet\leftarrow i}$ (to connectedness), is defined as

$$C_{\bullet\leftarrow i} = \frac{\sum_{\substack{j=1\\j\neq i}}^{N} \tilde{\theta}_{ji}^{g}(H)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ji}^{g}(H)} \times 100 = \frac{\sum_{\substack{j=1\\j\neq i}}^{N} \tilde{\theta}_{ji}^{g}(H)}{N} \times 100$$

Finally, the net directional connectedness transmitted from variable i to all other variables $C_i(H)$ (net connectedness), is defined as

$$C_i(H) = C_{\bullet\leftarrow i}(H) - C_{i\leftarrow\bullet}(H)$$

4.2 Selection & Shrinkage of the Approximating Model

First, we estimate inflation connectedness among 12-groups. The results call for a more detailed analysis to understand the inflation dynamics better. We achieve this goal by looking at more disaggregated levels in our analysis. The main intuition behind using large number of subcategories is the search for the origin of the shocks which will be informative to reveal the propogation channels of shocks within the system.

Using large number of variables in a VAR setting has one downside: the degrees of freedom will be quickly consumed by the procedure. Thus, to increase the number of observations, we will be in need of a longer estimation period. On the other hand, extending the estimation period hinders the correct estimation of the change in the coefficients over time. To deal with this problem, we use selection and shrinkage methods following [Demirer et al., 2017].

The elastic net estimator ([Zou and Hastie, 2005]) solves

$$\hat{\beta}_{Enet} = \arg\min_{\beta} \left(\sum_{t=1}^{T} \left(y_t - \sum_i \beta_i x_{it} \right)^2 + \lambda \sum_{i=1}^{K} \left(\alpha |\beta_i| + (1-\alpha) \beta_i^2 \right) \right).$$

Elastic net is an estimator which combines a LASSO (Least Absolute Selection and Shrinkage Optimization) L_1 penalty and a ridge L_2 penalty. We have two tuning parameters, λ and $\alpha \in [0, 1]$. An important point is that elastic net is lasso when $\alpha = 1$ and ridge when $\alpha = 0$. Unlike lasso, which may move only one of the strongly correlated predictors, elastic net makes sure that the these predictors are in or out of the model together with the aim of improving prediction accuracy relative to lasso.

The adaptive elastic net estimator ([Zou and Zhang, 2009]) solves

$$\hat{\beta}_{AEnet} = \arg\min_{\beta} \left(\sum_{t=1}^{T} \left(y_t - \sum_i \beta_i x_{it} \right)^2 + \lambda \sum_{i=1}^{K} \left(\alpha w_i |\beta_i| + (1-\alpha) \beta_i^2 \right) \right),$$

where $w_i = 1/\hat{\beta}_i^{\nu}$ with $\hat{\beta}_i$ the OLS estimate (or ridge if regularization is needed). Adaptive elastic net is also a mix of two estimators which are adaptive LASSO and elastic net. It blends the good properties of two estimators. It has the oracle property like adaptive LASSO and exhibits advanced predictor handling with highly correlated predictors like elastic net.

We will take $\alpha = 0.5$ without cross validation[1] and use 10-fold cross validation to choose λ. We use OLS regression to obtain the weights w_i.

4.3 Graphical Display

As a significant contribution of [Diebold and Yılmaz, 2014], the connectedness measures constitute weighted, directed and complete networks. In these networks,

[1] Cross validating α adds little to the estimation quality while requiring highly time consuming computations

Figure 1: Network Graph Color Spectrum

the nodes are 12 major consumption subcategories. Those nodes imply 12×12 edges. We calculate the network statistics by using all the observations available. For detailed analysis, we select the data frame that we would like to focus on or compare, e.g. pre-crisis versus post-crisis.

To determine the node locations, we use ForceAtlas2 algorithm developed by Jacomy et al. [Jacomy et al., 2014], as implemented in Gephi. The algorithm finds a steady state in which repelling and attracting forces exactly balance, in which (1) nodes repel each other, but (2) edges attract the nodes they connect according to average pairwise directional connectedness "to" and "from". The steady state node locations depend on initial node locations and hence are not unique. Since little attention is paid to the absolute locations of the nodes as opposed to relative locations, this is largely unimportant. Although we have only 12 nodes, we follow some rules for graphical display to make the networks comparable and easy to interpret. We color the nodes in accordance with the consumption subcategory's total directional connectedness "to others", ranging from 90EE90 (light green), to FFFF00 (yellow), to EEC900 (gold), to FF7F00 (dark orange), to EE0000 (red), to 8B0000 (dark red), as shown in Figure 1. A less influential consumption subcategory in the sample will appear light green whereas a highly influential subcategory will appear closer to dark red. We decide on the cutting points by taking the 0.3, 0.6, 0.9, and 0.95 percentiles of the "to" connectedness measures of all the subcategories throughout the dynamic analysis sample. We use the edge color to get clear graphics. Edge thickness indicates average pairwise directional connectedness, the lighter the weaker.

5 Static Estimation of the Inflation Network

The full-sample connectedness analysis provides a good characterization of "unconditional" aspects of the connectedness measures. In this section, we analyze the full-sample inflation connectedness among disaggregated inflation measures. We observe the spillovers within each European Union member country, and focus on the common spillover patterns. Investigating the country-specific inflationary shocks that are mostly coming from national health and education reforms are out of the scope of this paper.

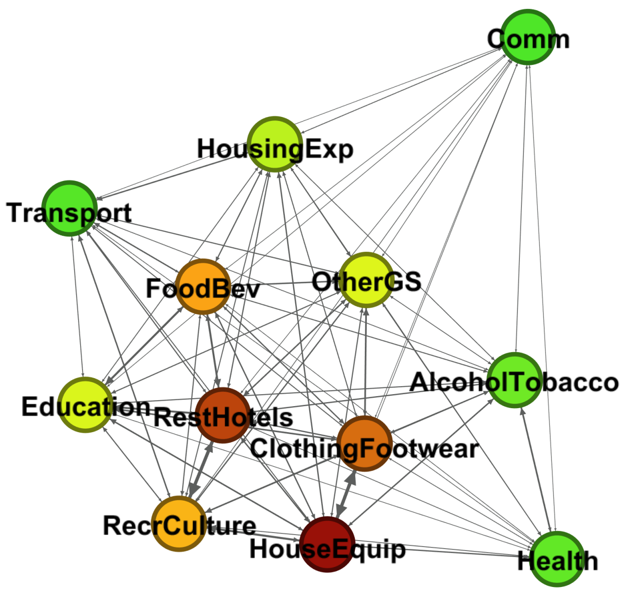

Figure 2: Full sample Network (Feb 1996 - March 2017) of EU's 12 Consumption Groups

The spillovers among the consumption subcategories is a macroeconomic question that may be related to many factors. We attempt to point out some significant determinants of the network structure and relate them to consumption habits. ECB has major efforts for standardizing the data collection among EU countries, thus we rely on the HICP data in obtaining comparable networks.

The immediate observation from the network in Figure 2 is the Education and Health's low levels of "to" connectedness. The advanced economies included in the European Union have big proportion devoted for education and health in their

Table 4: **Full Sample Connectedness Table for EU28:** The sample is February 1996 through March 2017, and the predictive horizon is 12 months. The ij-th entry of the upper-left 12 x 12 CPI component submatrix gives the ij-th pairwise directional connectedness; i.e., the percent of 12-month-ahead forecast error variance of component i due to shocks from component j. The rightmost (FROM) column gives total directional connectedness (from); i.e., row sums (from all others to i). The bottom (TO) row gives total directional connectedness (to); i.e., column sums (to all others from j). The bottommost (NET) row gives the difference in total directional connectedness (to-from). The bottom-right element (in boldface) is total connectedness (mean "from" connectedness, or equivalently, mean "to" connectedness).

	FoodBev	**AlcTob**	**ClothFootw**	**HousingExp**	**HouseEquip**	**Health**	**Transport**	**Comm**	**RecrCulture**	**Education**	**RestHotels**	**OtherGS**	**FROM**
FoodBev	55.864	2.260	3.271	4.821	6.880	1.489	2.033	0.533	2.396	7.334	7.550	5.569	44.136
AlcoholTobacco	3.938	51.131	5.792	2.786	7.512	9.623	1.478	0.644	4.239	4.377	6.215	2.264	48.869
ClothingFootwear	6.323	3.453	42.235	1.635	23.584	1.034	1.012	0.206	5.925	6.238	3.909	4.448	57.765
HousingExp	5.588	1.973	4.112	57.631	6.676	1.590	5.714	2.113	3.922	3.000	5.375	2.305	42.369
HouseEquip	5.102	3.551	21.421	2.401	42.270	2.509	1.313	0.741	6.889	4.173	7.179	2.451	57.730
Health	1.298	3.408	2.061	1.858	6.315	74.369	0.277	0.877	2.592	1.174	2.029	3.741	25.631
Transport	6.834	2.213	3.791	6.931	3.624	1.534	53.940	0.644	7.616	3.015	5.176	4.683	46.060
Comm	1.072	2.261	0.611	2.969	1.058	0.845	0.831	85.722	1.628	1.148	1.029	0.827	14.278
RecrCulture	4.728	1.634	8.429	2.760	13.026	1.172	3.209	0.205	36.283	1.935	23.674	2.946	63.717
Education	12.983	2.122	8.847	1.370	8.187	1.323	2.212	1.081	5.036	40.226	11.905	4.708	59.774
RestHotels	11.663	1.971	6.367	3.945	7.237	1.418	2.768	1.213	15.962	4.648	35.448	7.360	64.552
OtherGS	7.712	2.241	9.830	5.334	4.909	2.866	2.958	1.187	6.455	3.787	5.874	46.846	53.154
TO	67.240	27.088	74.532	36.810	89.009	25.404	23.806	9.444	62.661	40.828	79.916	41.300	**48.170**
NET	23.104	-21.781	16.766	-5.560	31.279	-0.227	-22.253	-4.834	-1.056	-18.946	15.363	-11.855	

average consumption basket. Yet, the price shocks to these categories do not translate into amplified inflationary effects. Communication is always a shock receiver, which is not a surprise given the constantly improving technology and decreasing costs with competition on the consumer side [2]. The central role of House Equipments in transmitting the shocks from Food & Beverages to Transportation is also noticeable and consumption habits' role in the transmission of shocks should be investigated. This observation is closely linked to their consumption commitments - the overall level of consumption that the consumers would like to maintain over time. This mainly explains the central position of Food & Beverages, given it has the highest weight in an average household's consumption basket. Tight relation observed between Recreational & Cultural Activities and Restaurants & Hotels is sensible when we think of them as luxury groups that one can give up for adjusting the overall consumption level for incoming shocks, yet further investigation at more disaggregated level may paint the picture better. These two categories are not only similar on the demand side, but also on the supply side. Many hotels and restaurants provide recreational activities as well, such as a concert venue offering the concert tickets (RecrCulture) and dinner(RestHotels) together.

Lastly, inflation connectedness between House Equipment and Clothing & Footwear shows the commonality among the shocks received. Clothing items and furnishings use the same inputs in production. The close relation of these subcategories imply that the pass-through of price increases in the textile sector is high. The network indicates that an unexpected price increase in natural gas (heavily fall under Housing Expenses) is reflected in the headline inflation not only directly by its own percentage change, but also with its spillover effects on other subcategories such as Alcohol & Tobacco. We deepen our analysis to see the causes of inflation connectedness at more disaggregated level.

[2]See Appendix for the networks of EU member countries.

5.1 Static Estimation for the 37 subcategories

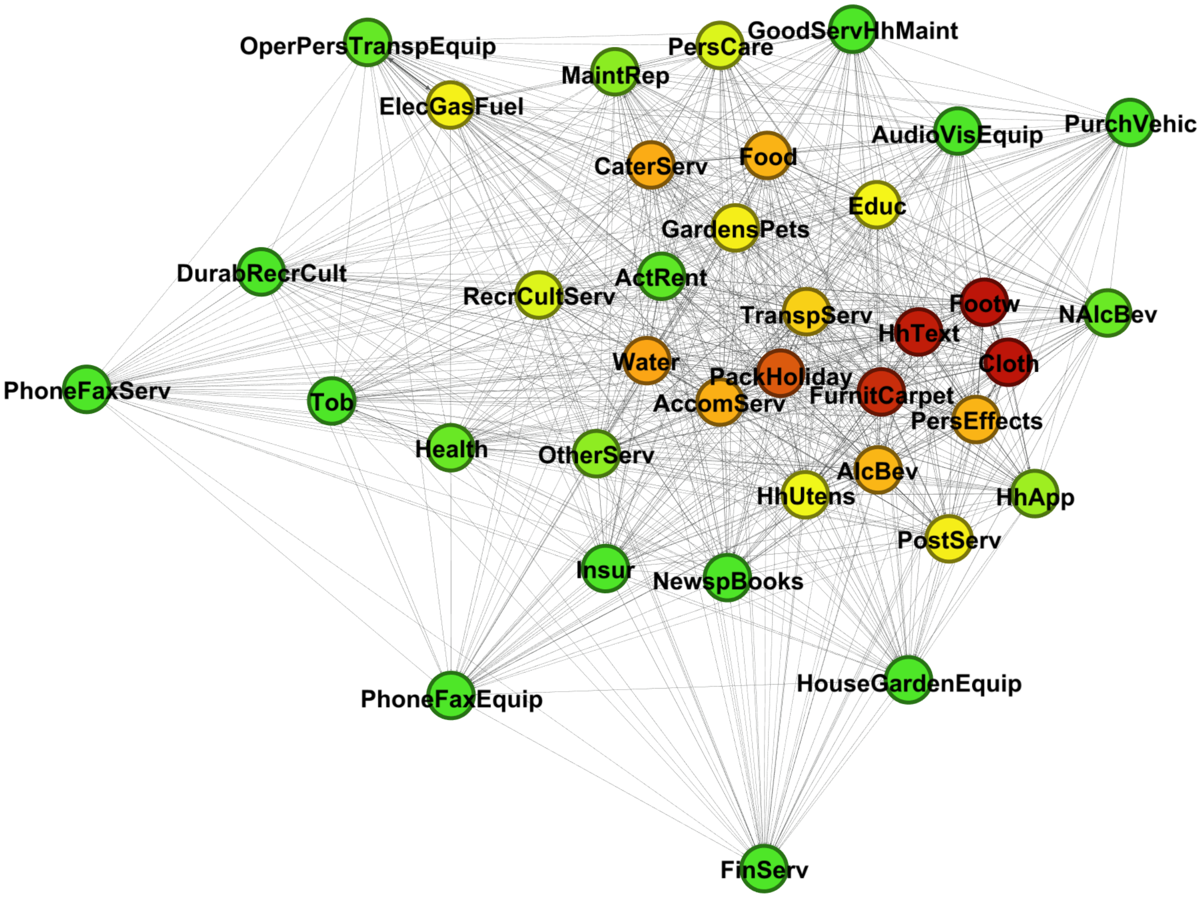

Figure 3: Full sample Network (Feb 1996 - March 2017) of EU's 37 Consumption Groups

In Figure 3, we observe the cluster of textile products (Clothing, Footwear, Furniture Furhishings Carpets and Houhehold Textile) as the shock-givers to the system. At this disaggregated level, we can better assess the close relation between ClothFootwear and HouseEquip in Figure 2. Deeper investigation indeed yields interesting results. Operation of Personal Transport Equipment (Transport) includes gasoline expenses for personal vehicles, hence its relation with Electric Gas and Other Fuels (HousingExp) reflect the co-movement energy prices.

As expected, Package Holidays and Accommodation Services have a tight relation. These service products are mostly (except for cruise holidays) consumed together, so we would expect a similarity in their inflation characteristics. Moreover, Transportation Services (including plane, bus tickets) display closeness with the two consumption groups, in line with a possible bundling in consumption. These stylized facts are simple and intuitive, signaling the health of the data and our estimation. The suppliers of Catering Services purchase final food products (Food), and hence we see a tight relation when we observe the edge thickness.

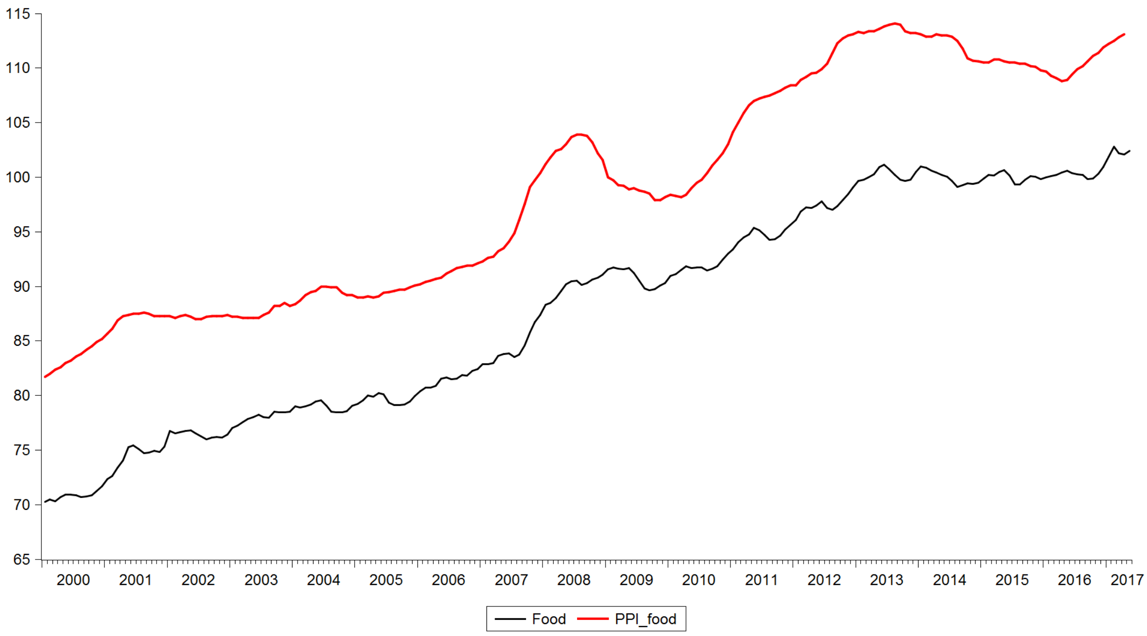

Figure 4: Producer Price Index for Manufacturing of Food Products and Food HICP

The substantial increase in cotton prices PPI for textiles in 2011 led to an increase in consumer prices for Clothing & Footwear, Household Textiles and Furniture Carpets etc. In addition, the fact that the EU crisis was over and the economies started to grow slowly but steadily enabling producers to reflect the cost increases on retail prices for these goods with income elastic demand. The increasing trend in these prices tend to generate significant connectedness to oth-

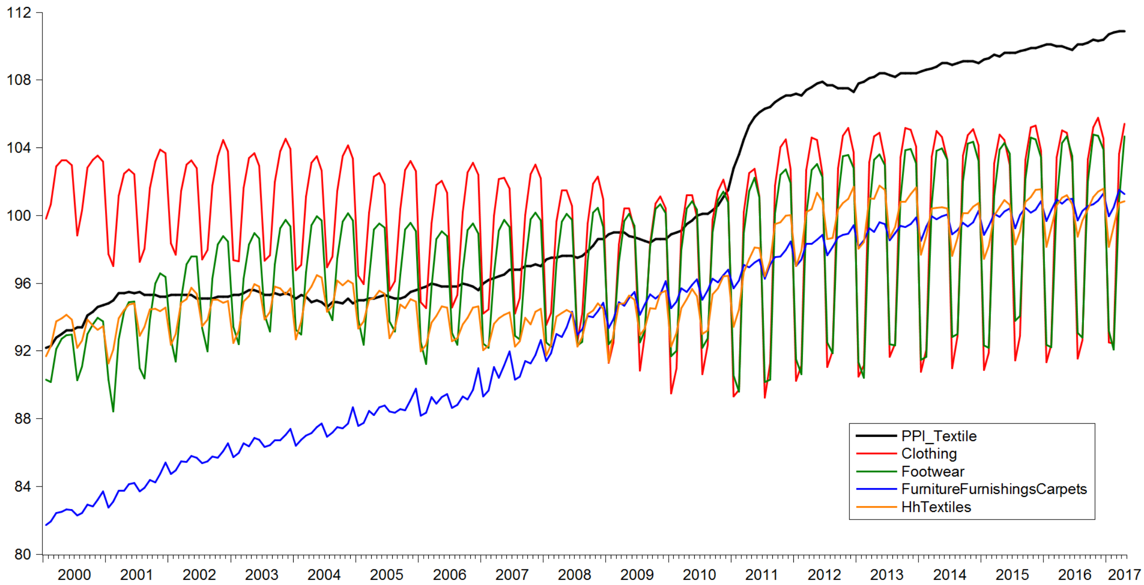

Figure 5: Producer Price Index for Textile Products and Textile HICP

ers in the 37-group analysis. Food prices however increased in 2007-2009, went through correction (for PPI and flat for CPI) in the 2nd half 2008 and 2009. In 2011-early 2012 it gained back what it lost earlier in 2008-2009. Hence, unlike Clothing & Footwear there is not much increase in food after 2012.

Overall, we see that consumption groups with inelastic demand like Food & Beverages are at the shock receiving end. In contrast, consumption groups that consumers can decrease consumption in, like Clothing & Footwear, are the shock givers to the system as their supply-side price shocks cannot be healthily transmitted in the system. Our study shows that the spillovers from the textile products are high and consistent, as the increase in commodity prices cannot result in a cost-push inflation. At times of financial crises, like the 2007-2008 Financial Crisis, the households cut back on their consumption in certain consumption groups. This cut leads to a break in the input price shocks transmission to output prices, as we can simply observe in Figure 5. On the other hand, increases in PPI for food manufacturing seems to be reflected in the consumer prices pretty quickly, as in Figure 4.

6 Dynamic Estimation of the Inflation Network

The full-sample connectedness analysis does not help us understand the connectedness dynamics. The appeal of the connectedness methodology lies with its use as a measure of how quickly inflation shocks spread within a country. This section presents the dynamic connectedness analysis which relies on 12-month-ahead forecast error variance decompositions of 60-month rolling estimation windows.

6.1 System-Wide Connectedness

6.1.1 Across 12 Subcategories

The system-wide inflation connectedness indices are traced across time. The time-varying properties of Diebold-Yilmaz Connectedness Index (DYCI) include common patterns as well as some important distinctions. As evident in Figure 7, there are common movements in all countries' DYCI. At the beginning of 2007, the break of the financial crisis, countries experience a decline in their total connectedness. The crisis results in all-time-low indices for the sample, indicating that the consumption groups become less connected. This may seem counterintuitive since the literature on financial markets suggest at times of financial distress, the connectedness increases. However, we are observing supply and demand side pressures on prices here, so it is sensible for consumption groups to be absorbing shocks themselves. Additionally, the correlations between the DY Connectedness indices, shown in Figure 5, are notable. These correlations capture the overall similarities and differences among different countries' total connectedness. Time variability in total connectedness seems to have common ground in most of the countries, with a separation among the core EU15 and 13 newcomers.

The inflation connectedness in EU countries become especially relevant in analyzing the effects of domestic policies. Eurozone countries are subject to the same monetary policies imposed by ECB and this enables us to control for monetary

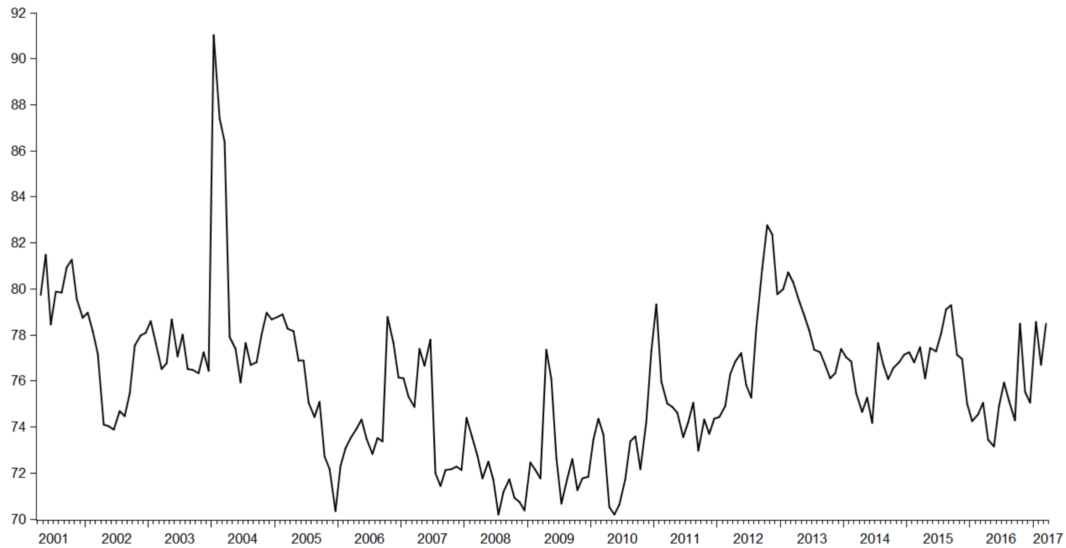

Figure 6: DYCI for EU28's 12 Consumption Groups

policy. For all countries investigated, we see that the D-Y Connectedness Index remains high throughout the sample with several peaks. This shows the persistence of the relation among consumption groups, and the peaks coincide with shifts in domestic policies. Healthcare reforms, taxes and educational regulations that apply only domestically are important structural events who have big but transitory effects. In that regard, EU provides a perfect setting with its centralized monetary authority. A complimentary investigation would be comparing policy differences among the states of US, yet there is no disaggregated data at state level.

Let us begin by considering the EU28 inflation network. From a bird's-eye perspective, the system-wide connectedness plot in Figure 6 has some interesting patterns. It has three cycles: reaching local peaks around mid-2001, beginning of 2004, end of 2012. The other cycle starts in mid-2016 and is ongoing. The significant jump from 75% in Jan 2004 to 91% for a few months can be related to the inclusion of ten new countries to the European Union. This jump can be linked to the asset price boom of 2004, pushing up CPI by affecting import prices. Admittedly, there exist seasonal effects. Since we are interested in all the inflation dynamics including the seasonal effects, we do not correct for this and we interpret accordingly.

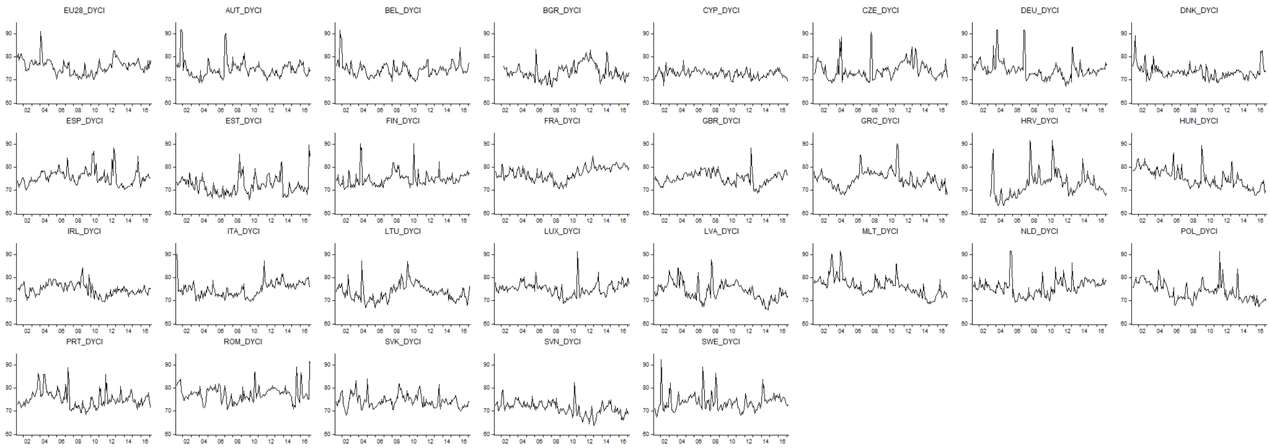

Figure 7: DYCI across Consumption Sub-categories in EU28 Member Countries

6.1.2 Across EU Countries

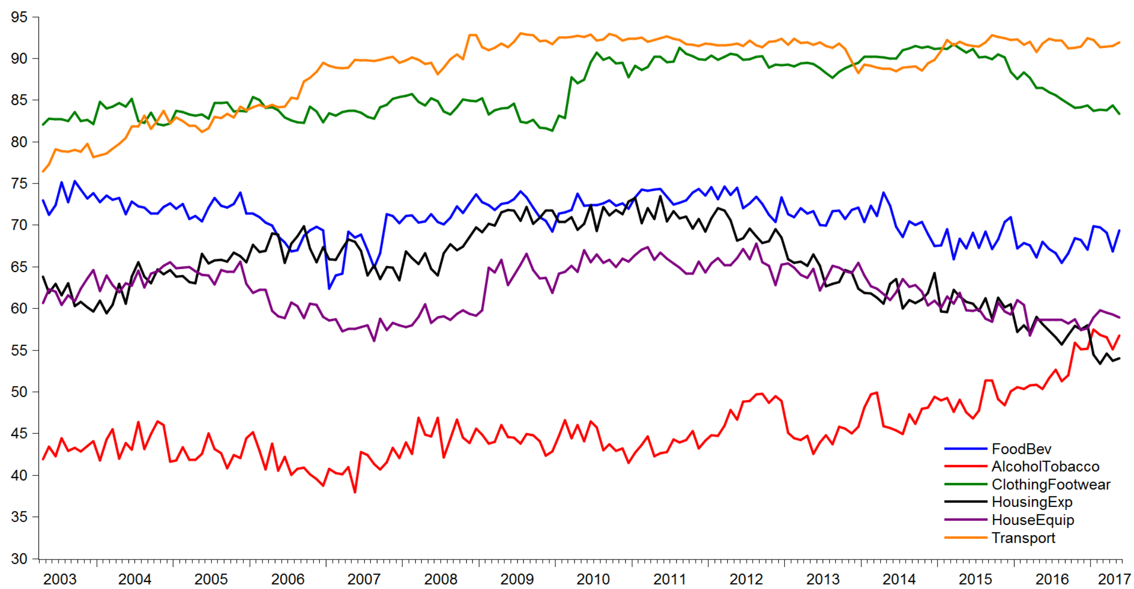

Figure 8: DYCI for 12 Consumption Groups across EU Countries - I

The dynamic D-Y Connectedness Indices in Figures 8 and 9 are quite revealing. First, Clothing & Footwear and Transport had high connectedness across EU28

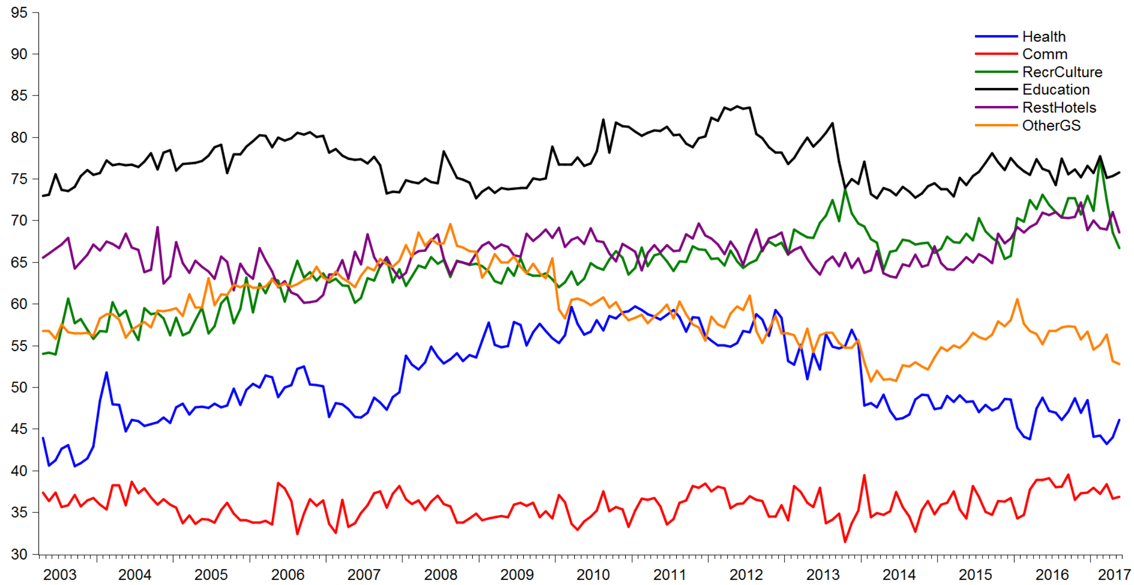

Figure 9: DYCI for 12 Consumption Groups across EU Countries - II

and increased even higher before some correction in 2015 and 2016. These two groups are the most heavily traded ones, and they faced inflationary pressures in 2011. In addition, the fact that the EU crisis was over and the economies started to grow slowly but steadily enabling producers to reflect the cost increases on retail prices for these goods with income elastic demand. Other than the correction period during 2014, Transport seems to have reached a stable connectedness level since the start of 2009. Transport has the highest connectedness throughout our sample period, which is in line with its early convergence to a high level of openness to trade, especially in terms of Purchase of Vehicles.

Food & Beverages group has a stable high connectedness across the EU28. This fact may partly be related to the commonality of the shocks faced by different countries, as global food prices drive the market. Food prices increased in 2007-2009, went through a correction (for Producer Price Index of Manufacturing Food Products) in the 2nd half of 2008 and 2009. In 2011-early 2012 it gained back what it lost earlier in 2008-2009. Those volatile movements has caused supply-push inflation, making Food & Beverages one of the most connected groups. Also, as evident from Table 2, the consumption basket weight for Food & Beverages follow a similar path with the DYCI. Its highest level was in 1998 and it has been up and down around 15% since 2003. Only, DYCI is successful in capturing the 2007-2008 Financial Crisis, and experiences its most volatile times in 2007.

Education has high connectedness across EU28 and it tends to stay high. This high level is mostly related to tertiary education, which increasingly drives global demand for EU. United Kingdom, Germany and France are the leading countries to attract international students for tertiary education. Countries have seen a major increase in the educational attainment level of their populations, and this is not specific to EU. According to [OECD, 2017], in 1965, only 43% of adults aged 25-34 attained upper secondary education or higher across OECD countries. In 2015, upper secondary education had almost doubled with attainment levels reaching 84%. Many researchers studied globalisation's effect on the higher education sector during the last decade, and our results comply with [Altbach and Knight, 2007] and [Marginson and Van der Wende, 2007]. Higher education institutions are increasing intakes and opening new programs, yet they still cannot keep up with the global demand hike. Our observations are in line with the education literature, and we project that connectedness of education will follow its upward trend in the coming years.

Alcoholic Beverages & Tobacco was low at the beginning, but is picking up lately. This observation is valuable in showing the policy harmonization in the EU as ambitiously aimed by European Parliament's "EU Alcohol Strategy". The parliament developed the strategy to reduce alcohol-related harm and apply EU-wide measures such as imposing EU harmonized excise duties. Although this specifies only the minimum level of excise duty, there is significant convergence in the excise duty rates across EU. The prices of alcoholic beverages and tobacco products are highly responsive to taxation policies, and homogeneity across EU members are highly desired.

On the other hand, Housing Expenses seem to have the exact opposite pattern after 2013, resulting in a reversal in relative position at the beginning of 2017. The plummeting energy prices in the second half of 2008 has driven connectedness up, until 2011. With the surge in commodity prices and the relief in rents, connectedness tends to be decreasing fast. The house prices picked up from the start of 2013, reaching to pre-crisis level only recently in January 2016. Housing Expenses pose intriguing questions to uncover the inflationary dynamics behind, and those could shape a future research direction.

The service sectors, mostly considered as nontradable, exhibit lower levels of connectedness. Communication is the less connected sector in our sample, and its low level is quite stable. Communication services tend to serve domestic demand, and it is particularly on the supply side. As [Roura et al., 2002] covers in dept, services are being increasingly traded globally. The steady increase in the connectedness of Recreational & Cultural Activities across EU is a positive development on this side.

The heterogeneity across countries in health policy implementation explains the lowering levels of total connectedness across EU28 in Health. Average annual growth in per capita health spending is growing slowly after hitting the rock bottom in 2010 (-1% in real terms). Implementation of new policies decreased the out-of-pocket payments by patients in the 3rd quarter of 2013, and this has intensified the heterogeneity and caused the connectedness to fall drastically. European Commission thrives to stimulate across-borders health spending, but EU lags behind other OECD countries [OECD, 2015]. The cross-border supply of healthcare services and the consumption of services abroad have significant room for development. This calls in the need for harmonization of health policies, as in the case of Alcoholic Beverages & Tobacco.

Restaurants & Hotels is a consumption group who is highly responsive to the economic conditions. Although it has a fair weight in an average EU household's consumption basket, it surely is income elastic. We observe the lowest levels for Restaurants & Hotels connectedness at the end of 2006, and it has been mostly increasing since then. As reported by Eurostat [eurostat ref here], the rented accommodation including hotels and campsites comprised 77% of the accommodation for intra-EU inbound trips in 2015. We can relate the increasing connectedness both in Restaurants & Hotels and Recreational & Cultural Activities to the increased popularity of hotel booking and entertainment ticket search websites. With the usage of such websites enabling consumers to plan and book their travel online, we can talk about a global market for restaurants, hotels, recreational activities and all other tourism activities. We observe this effect in the connectedness measures, despite the terrorism attacks harming tourism globally.

Other Goods & Services group includes Insurance and Financial Services as the major subcomponents. The sharp decline in this group's connectedness after the break of the financial crisis is notable. [Demirer et al., 2017] shows that equity connectedness increase during this period due to cross-country changes, and we observe the inflation connectedness across EU to be decreasing with the crisis. With the end of the European Sovereign Debt Crisis, we observe a recovery in the cross-country connectedness. Inflation spillovers across EU at the disaggregated level has numerous aspects that can be researched, and we leave a wider investigation taking other indicators into account to future research.

6.2 Pairwise Directional Connectedness

Once we perform the rolling-window estimation, we obtain the pairwise directional connectedness measures that vary throughout the sample. These measures quantify the bilateral relations among EU countries, and we focus on the correlation between every country's measures with their aggregate EU28 counterpart.

Figure 10 depicts the correlation among pairwise connectedness measures of member countries with EU as a whole. Since we would like to see how much the

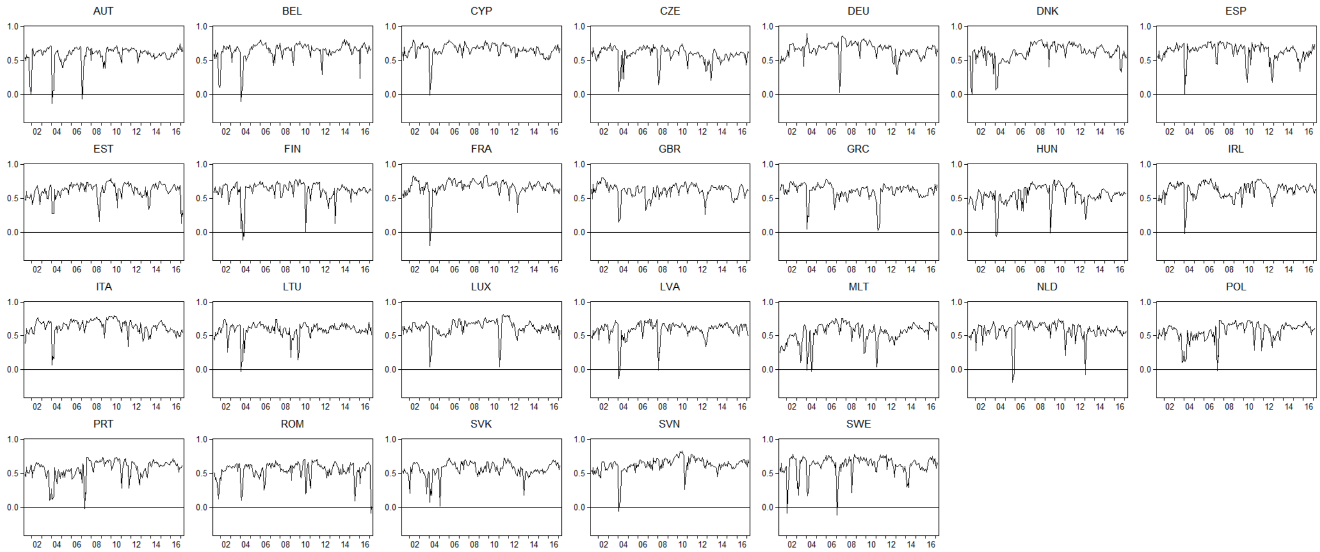

Figure 10: Correlation of EU's pairwise connectedness measures with member countries'. Bulgaria and Croatia are left out since their data become available in 2002 and 2003 as opposed to 2001.

pairwise connectedness measures resemble to the EU correspondent, this analysis is of interest. Our first observation from this analysis is the stability of the levels. Since we center upon the pairwise connectedness across different consumption groups, this stability refers to a persistent relation among them. Once an income elastic group will not transform into being income inelastic in short time. However, we see a upward trend in almost all countries' correlation after the commodity price surge of 2014.

Additionally, we observe the volatile upwards movements in new EU members such as Cyprus, Czech Republic, Hungary, and Malta. These could be signs of integration to the EU, yet more detailed investigation is required to draw this conclusion. Low and stable inflation is a precondition to become an EU member state, enabling us to contrast and compare the countries without minding too much about the inflation levels. The months where correlations hit zero or turn to negative imply that there is a significant shock to the system, and we track them to be structural changes. The sharp decline in the correlation observed in some countries at the beginning of 2004 is due to a major health reform adopted by Germany. In this period, Germany's correlation with EU28 increased whereas almost every other countries' declined. The plummet in correlation right at the beginning of 2006 coincides with the huge structural changes in national policies, all in line with the European Commission policy recommendations.

7 Conclusion

In this study, we employed monthly data on Harmonized Index of Consumer Prices at the disaggregated consumption groups level. We have gone beyond the headline inflation and emphasize that, the indirect contribution of subcategory price changes to the headline inflation can be as important as their direct contributions. Many central banks that adopted inflation targeting strategies monitor and target the core inflation measures. Excluding food and oil prices from the CPI calculation by their consumption weights may not suffice, neglecting the spillover effects may cause mistargeting. Once received, oil price shocks are transmitted to other consumption groups, as the consumers cannot adjust to rising costs immediately. We have identified and quantified these effects in this study, aiming at more effective monetary policy-making.

First, we have shown that the networks of EU countries have significant resembling. The networks tend to have consumption goods like Clothing & Footwear and Housing Equipment at central positions whereas services tend to be peripheral. The differences in inflation networks of different countries appear in those who received a national policy shock. We employ rolling-window estimation to reveal the dates that the pairwise connectedness measures change, and we dig in for EU-wide and country-specific policies at those dates.

Additionally, we have analyzed the connectedness across EU28 separately for each major consumption group. Our results point to the differences between tradable and nontradable goods and services, and every consumption groups' transformation in that regard. We have showed that the connectedness measures capture trade integration trends across time, and the switch from nontradables to tradables. European countries seem to be following the European Central Bank advice: "produce machines, not houses". Education, Recreational & Cultural Activities and Restaurants & Hotels have the most intriguing intra-EU spillovers. Already highly connected groups like Food & Beverages and Transportation seem to be preserving their connectedness level. We project that the connectedness across EU as well as across consumption groups will increase, and this will complicate further the already complicated policy-making. Research on policy-making through more detailed analyses of macroeconomic indicators is highly relevant. It is open to question how Brexit will disturb the balances, yet most recent developments are pointing to vanishing borders and increased trade.

Going forward, our approach is fruitful. As more frequent and more disaggregated data becomes available, more detailed analyses uncovering the spillovers among consumption groups will be plausible. Thus, supply and demand shocks to consumption groups are to be better understood and managed by the policy-makers following this research line.

A Appendix

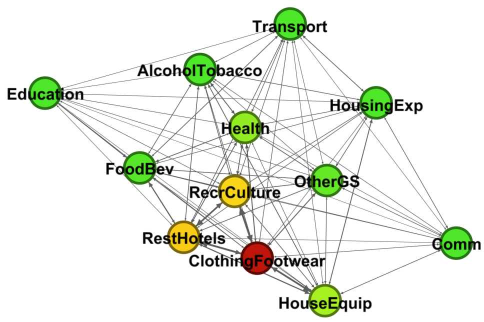

Figure 11: Austria

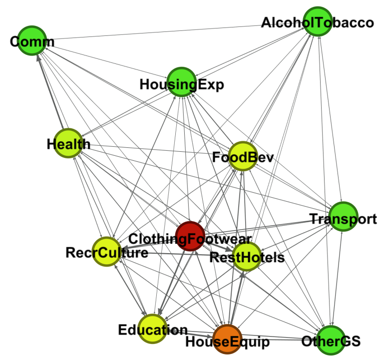

Figure 13: Bulgaria

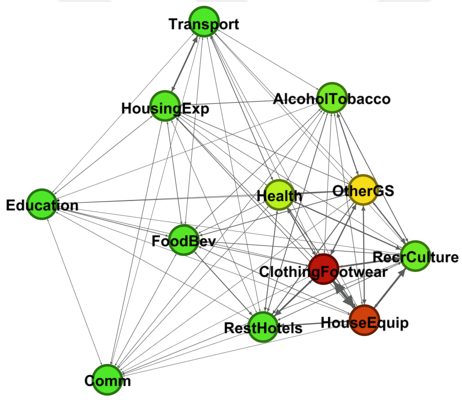

Figure 12: Belgium

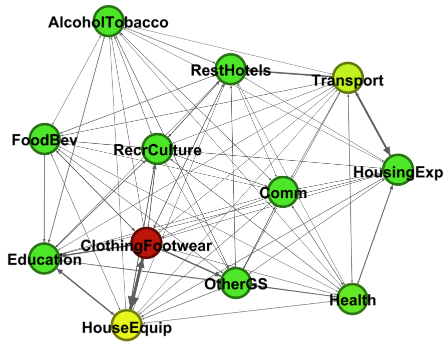

Figure 14: Cyprus

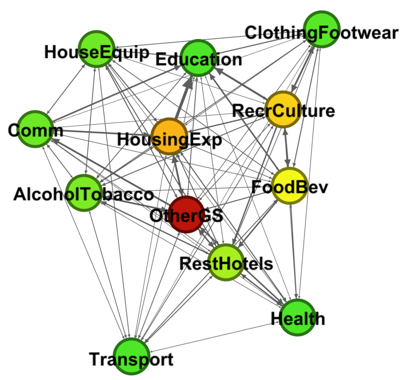

Figure 15: Czech Republic

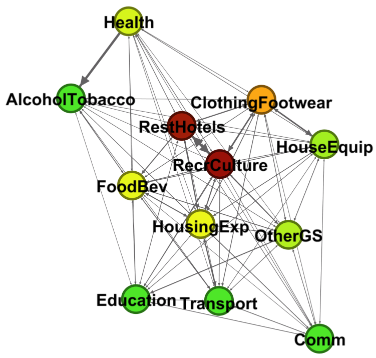

Figure 16: Germany

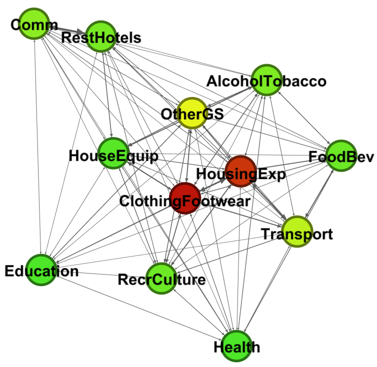

Figure 17: Denmark

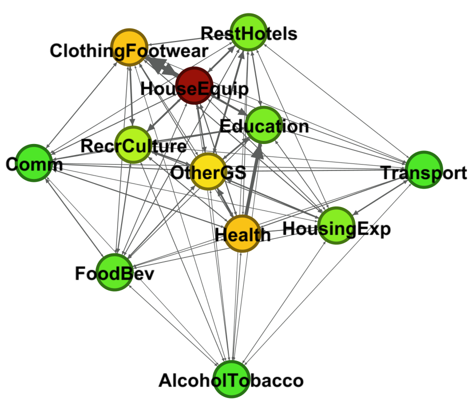

Figure 18: Spain

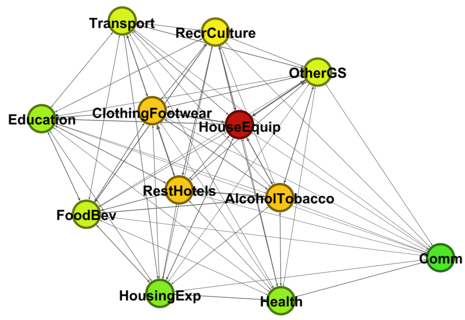

Figure 19: Estonia

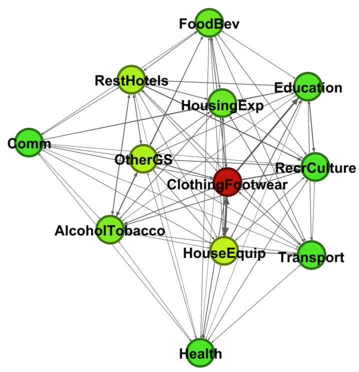

Figure 20: Finland

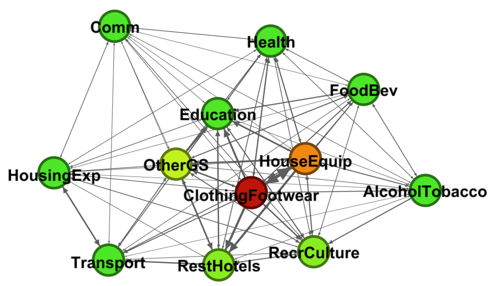

Figure 21: France

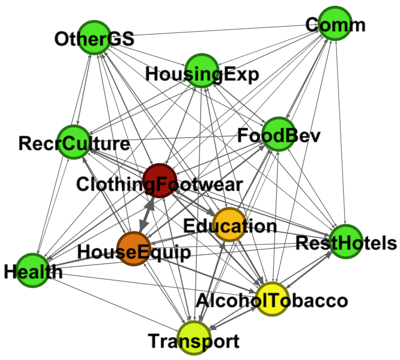

Figure 22: United Kingdom

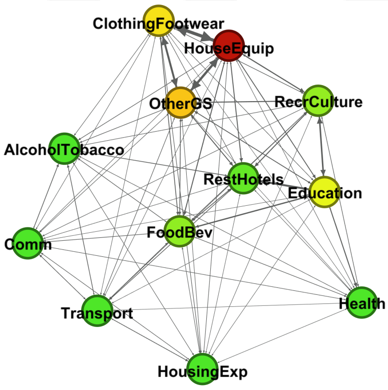

Figure 23: Greece

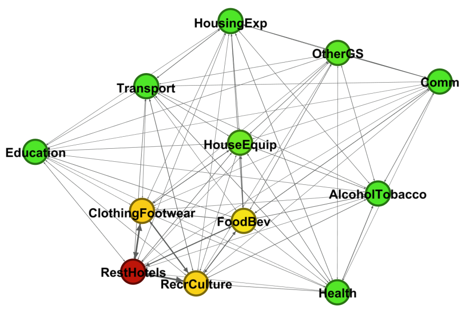

Figure 24: Croatia

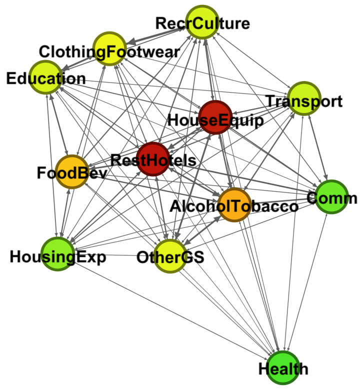

Figure 25: Hungary

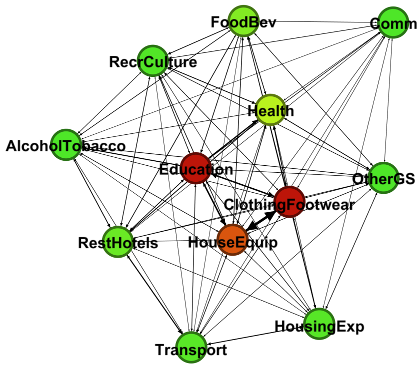

Figure 26: Ireland

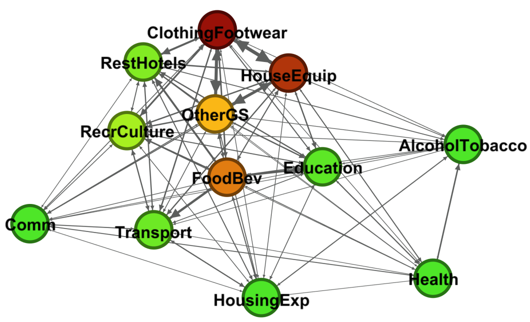

Figure 27: Italy

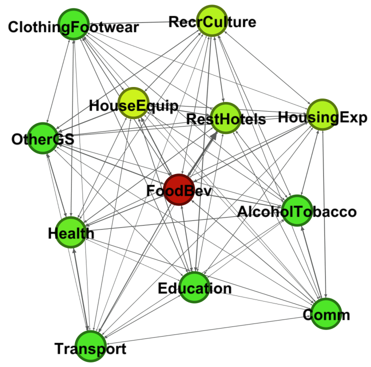

Figure 28: Lithuania

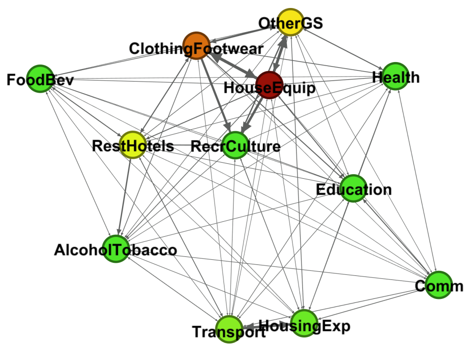

Figure 29: Luxembourg

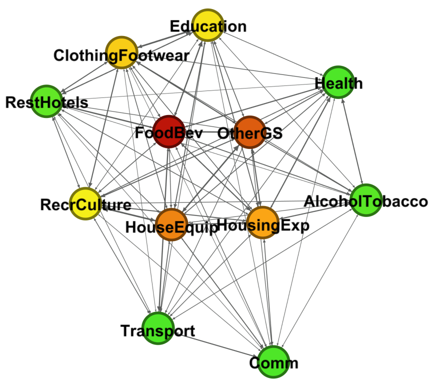

Figure 30: Latvia

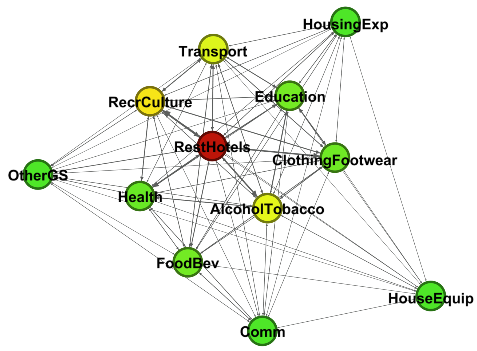

Figure 31: Malta

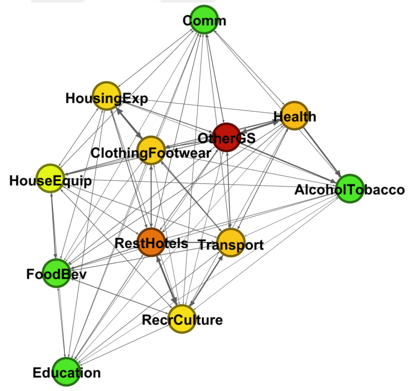

Figure 32: Netherlands

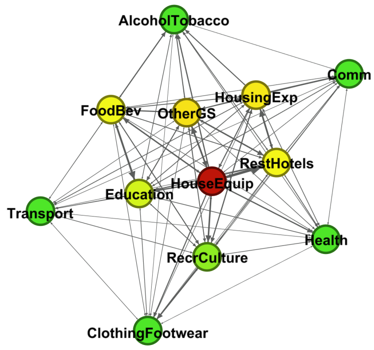

Figure 33: Poland

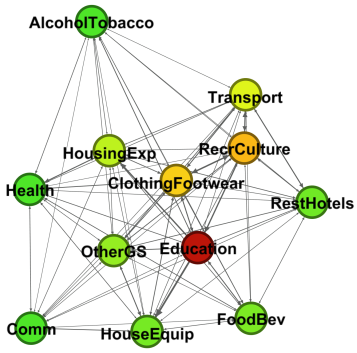

Figure 34: Portugal

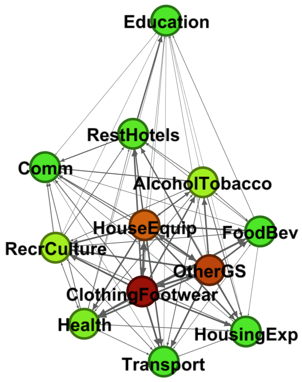

Figure 35: Romania

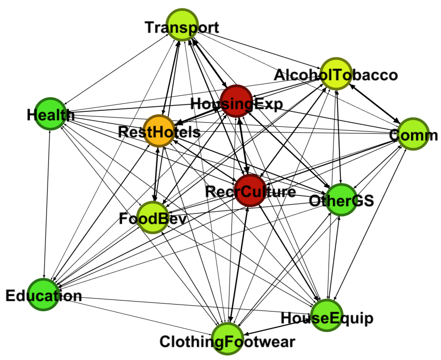

Figure 36: Slovak Republic

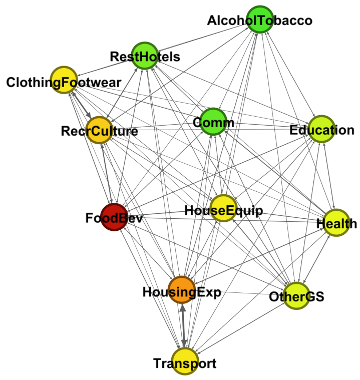

Figure 37: Slovenia

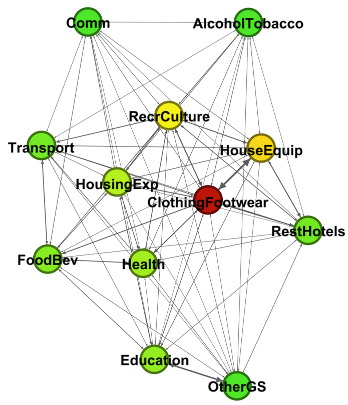

Figure 38: Sweden

Table 5: Correlation Table for EU Countries' DYCI

	EU28	AUT	BEL	BGR	CYP	CZE	DEU	DNK	ESP	EST	FIN	FRA	GBR	GRC	HRV	HUN	IRL	ITA	LTU	LUX	LVA	MLT	NLD	POL	PRT	ROM	SVK	SVN	SWE
EU28	1																												
AUT	-0.17	1																											
BEL	0.17	0.15	1																										
BGR	0.18	-0.16	-0.04	1																									
CYP	-0.02	0.14	0.17	-0.12	1																								
CZE	0.15	-0.11	0.18	0.28	-0.16	1																							
DEU	0.53	-0.05	0.17	-0.12	0.11	-0.07	1																						
DNK	0.10	-0.05	0.10	-0.29	0.01	0.05	0.17	1																					
ESP	-0.03	0.01	-0.07	0.13	0.03	-0.08	-0.01	0.00	1																				
EST	0.12	-0.13	0.08	0.23	-0.25	0.14	0.06	0.10	-0.02	1																			
FIN	-0.01	0.02	0.13	-0.03	-0.23	0.17	0.13	0.20	-0.07	0.31	1																		
FRA	0.53	-0.24	0.17	0.18	-0.17	0.20	0.05	-0.01	-0.16	0.09	-0.07	1																	
GBR	-0.08	0.16	0.13	-0.16	0.23	-0.09	0.01	0.10	0.32	-0.15	-0.01	-0.19	1																
GRC	-0.30	0.21	0.01	0.01	-0.03	-0.08	-0.16	-0.12	0.19	-0.11	0.00	-0.26	0.19	1															
HRV	-0.34	0.21	-0.06	0.06	-0.08	0.16	-0.26	-0.05	-0.17	0.14	0.09	-0.09	-0.12	0.40	1														
HUN	0.14	-0.22	-0.19	0.04	0.20	-0.06	0.21	0.13	0.13	-0.14	-0.08	-0.27	-0.05	-0.17	-0.34	1													
IRL	-0.17	0.14	-0.12	-0.38	0.17	-0.18	0.09	0.15	0.12	-0.10	0.08	-0.46	0.28	-0.11	-0.31	0.24	1												
ITA	0.27	-0.05	0.22	0.19	-0.23	0.16	-0.01	-0.07	-0.31	0.19	-0.02	0.55	-0.15	-0.28	-0.07	-0.34	-0.29	1											
LTU	-0.34	0.07	-0.08	0.24	-0.20	0.29	-0.28	-0.02	0.03	0.26	0.21	-0.25	-0.25	0.29	0.44	-0.13	-0.06	-0.21	1										
LUX	0.31	-0.06	0.13	-0.07	0.30	-0.05	0.36	0.14	-0.10	0.06	0.12	0.30	0.15	-0.15	-0.29	0.03	0.05	0.14	-0.31	1									
LVA	0.00	-0.24	-0.06	0.08	0.07	0.28	0.08	0.15	0.20	0.13	0.18	-0.17	-0.01	0.04	0.20	0.14	-0.07	-0.36	0.38	-0.07	1								
MLT	-0.02	-0.27	-0.28	0.06	0.17	-0.03	0.13	-0.03	0.11	0.01	-0.07	-0.29	0.00	-0.04	-0.07	0.36	0.08	-0.38	0.20	0.10	0.55	1							
NLD	0.23	-0.07	0.08	0.27	-0.05	0.12	0.05	-0.06	-0.19	0.19	0.05	0.35	-0.15	-0.21	-0.03	-0.04	-0.20	0.41	-0.10	0.24	-0.18	-0.09	1						
POL	0.08	-0.27	-0.05	0.26	-0.02	0.15	0.02	-0.13	0.07	0.20	-0.02	-0.08	-0.18	-0.14	-0.02	0.41	-0.13	-0.03	0.26	-0.07	0.37	0.43	0.12	1					
PRT	0.34	-0.17	0.04	0.01	0.21	0.06	0.46	0.13	0.00	-0.16	-0.17	0.17	0.03	-0.24	-0.30	0.24	-0.03	-0.02	-0.31	0.45	-0.02	0.28	0.03	0.14	1				
ROM	0.25	-0.01	-0.14	0.29	-0.16	-0.05	-0.06	-0.04	0.05	0.21	0.01	0.22	-0.08	-0.20	-0.13	0.02	-0.07	0.17	-0.09	0.09	-0.09	-0.06	0.28	-0.01	-0.07	1			
SVK	-0.04	0.11	-0.13	0.07	0.07	-0.20	0.05	-0.03	-0.05	0.11	-0.01	-0.31	0.00	0.27	0.26	0.07	0.04	-0.26	0.24	-0.12	0.15	0.31	-0.15	0.16	-0.07	-0.03	1		
SVN	-0.03	0.01	-0.11	-0.40	0.20	-0.22	0.16	0.09	0.02	-0.22	0.04	-0.30	0.19	0.11	0.15	0.18	0.26	-0.47	-0.14	0.00	0.11	0.15	-0.19	-0.04	0.12	-0.18	0.19	1	
SWE	-0.04	0.39	0.15	-0.28	0.15	0.00	-0.03	0.14	0.02	-0.19	0.09	0.01	0.20	-0.03	-0.04	0.01	0.21	-0.14	-0.20	0.14	-0.19	-0.16	0.04	-0.29	-0.02	0.05	-0.16	0.23	1

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